A. Introduction

Radioactive materials play key roles in our lives. Commercial nuclear power plants generate one-fifth of the electricity used by people living in the United States. Hospitals use special radioactive materials to diagnose and treat cancer and other diseases. Radioactive materials such as uranium and plutonium were used for the Cold War nuclear weapons program.

Managing the waste from these activities is a challenging environmental, technical, and political issue. Large quantities of waste need treatment, storage, and/or disposal. Selecting sites and constructing and managing disposal facilities that must isolate radioactive waste for hundreds or even thousands of years are complicated and controversial processes. Safely transporting waste to storage and disposal sites involves extensive planning and precautions, including route selection, waste packaging, security, carrier selection and training, and emergency response preparation.

The major focus of this guide is low-level radioactive waste (low-level waste) that is managed by the Department of Energy (DOE). DOE expects to manage nearly 9 million cubic meters of low-level and mixed (radioactive and hazardous) low-level waste and 26 million cubic meters of contaminated soil resulting from nuclear weapons production and research, basic science research, operation of nuclear powered submarines and ships, and cleanup of the vast network of former nuclear weapons production facilities. While low-level waste accounts for about 85 percent of the volume of all radioactive wastes (excluding uranium mill tailings), it accounts for only five percent of the radioactivity.

The DOE Office of Environmental Management manages low-level waste under different laws, depending on the waste source. Under the authority of the Atomic Energy Act, it manages low-level waste from operations activities, including past nuclear weapons production and ongoing research activities. Major Waste Management decisions are evaluated under the National Environmental Policy Act (NEPA). DOE manages contaminated media, including soil and water, and low-level wastes from cleanup activities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or the Resource Conservation and Recovery Act (RCRA). Although the vast majority of contaminated soil and low-level waste is managed on-site, either in place (contaminated soil) or in a special disposal cell, DOE anticipates that its annual shipments of low-level waste to DOE and commercial waste management facilities will increase over the next several years.

This guide only briefly addresses commercial low-level waste, and it does not address other radioactive waste, such, transuranic waste, and spent nuclear fuel from DOE or commercial power plants and other HL waste. DOE low-level waste is only one part of the significant quantity of radioactive waste that must be managed.

The purpose of this guide is to provide basic and accurate information about DOE management of low-level waste. It tries to explain material that is often technical and difficult in terms that interested individuals, local officials, and journalists can understand. Using a question-and-answer format, the guide presents some basic facts about low-level waste. It also provides a resource list of people, organizations, publications, and Web sites that can provide further information.

A Guide to the U.S. DOE's Low-Level Radioactive Waste was produced by the National Safety Council's Environmental Health Center under a cooperative agreement with the U.S. Department of Energy.

B. Radiation and Low-Level Waste

1. What is radiation?

All matter is composed of elements, and each element can take many different forms, called isotopes. The difference between isotopes of the same element is in their number of neutrons. Some isotopes are unstable and emit radiation, which is energy given off by atoms when they move or change state. These unstable isotopes are known as radionuclides. Stable isotopes do not emit radiation.

2. Where does radiation come from?

Radiation comes from both natural and manmade sources. Most of the radiation we are exposed to comes from natural sources, such as the sun's rays, soil, and water, and even our own bodies. These natural sources are referred to as background radiation.

Radiation also comes from a wide range of manmade sources including medical diagnosis and treatment, some consumer goods, operation of nuclear power plants, manufacture of nuclear weapons, and fallout from past nuclear weapons testing.

In the United States, an average of 82 percent of a person's exposure comes from natural sources. The largest single source is indoor radon which accounts for 55 percent of the average annual exposure. **(See figure 1.)** Radon is a radioactive gas that is colorless, odorless, tasteless, and chemically inert. It is a direct descendent from uranium. An average of 18 percent of our exposure comes from manmade sources. On average more than 90 percent of exposure from manmade sources comes from medical diagnosis and treatment.

3. What are ionizing and non-ionizing radiation? Which types of radiation does low-level waste emit?

Ionizing and non-ionizing radiation are the two basic categories of radiation. They are distinguished by the amount of energy involved.

Non-ionizing radiation has lower energy levels and longer wavelengths. It is not strong enough to affect the structure of atoms it contacts. Examples include radio waves, microwaves, visible light, and infrared such as that from a heat lamp. **(See figure 2.)**

Ionizing radiation has higher energy levels and enough energy to change the electric charge of atoms or molecules. There are three basic types of ionizing

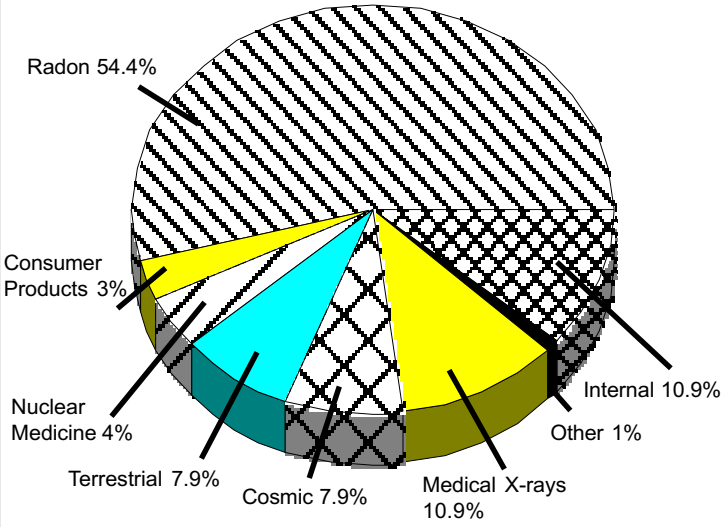

Figure 1. Sources of Radiation (Source: National Council on Radiation Protection and Measurements)

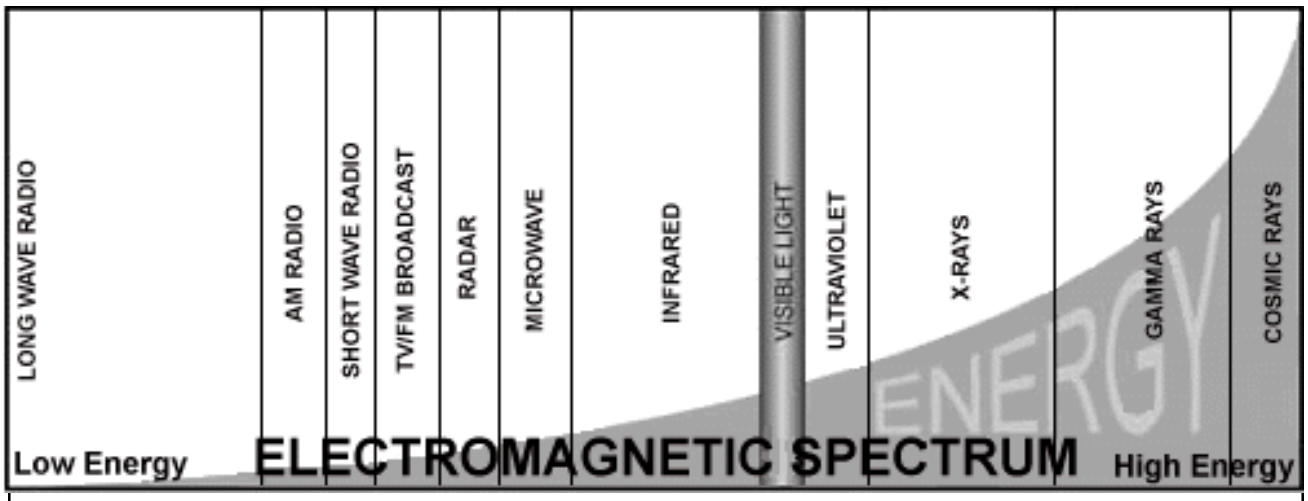

Figure 2. The Electromagnetic Spectrum. (Source: The Ohio State University)

radiation — alpha and beta particles and gamma rays — each with different energy levels, penetrating power, and other characteristics. **(See figure 3.)** Nuclear waste emits ionizing radiation.

- **Alpha particles** can travel only a few inches in the air and lose their energy almost as soon as they collide with anything. A sheet of paper or the outer layer of a person's skin can easily stop alpha particles. They are essentially helium nuclei and exhibit a positive charge.

- **Beta particles** move faster than alpha particles and can travel in the air for a distance of a few feet. Beta particles can pass through a sheet of paper but can be stopped by a sheet of aluminum or glass. They may exhibit a negative or positive charge.

- **Gamma rays** are rays of pure energy that travel at the speed of light through air or open spaces. Concrete, lead, or steel can block gamma rays.

Low-level waste, because it is broadly defined, may emit alpha, beta, and/or gamma radiation.

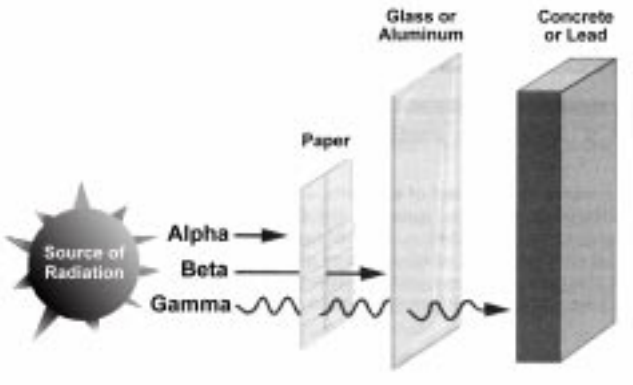

Figure 3. Materials That Block Different Rays.

4. How is radiation measured?

The presence of radiation can be easily detected using electronic equipment called Geiger counters and dosimeters. Units of measure used in the United States include:

- **Curie** — A curie is the basic unit used to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second, which is approximately the activity of 1 gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second. It is named for Marie and Pierre Curie, who discovered radium in 1898.

- **Rad** (radiation absorbed dose) — A rad is a measure of the amount of energy actually absorbed by a material, such as human tissue.

- **Rem** (roentgen equivalent man) — A rem is a measure of the biological impact of radiation. It takes into account both the amount, or dose, of radiation and the biological effect of the specific type of radiation. A **millirem** is one one-thousandth of a rem.

- **Roentgen**—A roentgen is a unit of exposure to ionizing radiation. It is the amount of gamma or x-rays required to produce ions resulting in a specific charge (0.000258 coulombs/kilogram of air) in one cubic meter of air under standard conditions.

5. What does "half-life" mean?

The "half-life" of an unstable radionuclide or element is the amount of time it takes for half of the radioactive atoms in the element to decay to a more stable form. After one half-life, half the radioactive atoms in a sample remain radioactive; after two half-lives, one-quarter remain radioactive; and so on. The half-life can vary substantially from one isotope to another, ranging from a fraction of a second for plutonium-214, to 8 days for Iodine-131, to 24 thousand years for plutonium-239, to billions of years for uranium-238. Some radioactive materials decay to other radionuclides that give off additional ionizing radiation. This can greatly increase the time the material would remain a public health concern.

Because one-half of the atoms remain radioactive after one half-life, the half-life is not a measure of when radioactive materials are no longer hazardous. The length of the hazardous life of a radioactive element is equal to approximately 10 or 20 times its half-life.

6. How long is low-level waste radioactive?

The levels of radioactivity of most low-level waste drop to natural background levels within a few months or years. About 95 percent of low-level waste decays to background levels within 100 years or less. Virtually all of it reduces to background levels in less than 500 years.

C. Radioactive Waste

1. What is radioactive waste?

Radioactive waste is radioactive materials that are no longer of any use, radioactively contaminated equipment, or the unused byproduct of using, refining, and processing radioactive materials. Almost all activities that use radioactive materials generate some radioactive waste. The waste can be in liquid, solid, or gas form.

2. What is low-level waste?

Low-level waste is basically radioactive waste that is not high-level waste, transuranic waste, or byproduct materials such as uranium mill tailings. **(See sidebar: *Other Major Categories of Radioactive Waste.*)** It usually contains small amounts of radioactive material with a short half-life dispersed in large quantities of material. However, in some cases low-level waste is highly radioactive. Typical Department of Energy low-level waste consists of such things as used gloves and other protective clothing, glass and plastic laboratory supplies, tools and equipment, used resins and residues, dirt, concrete, construction debris, and scrap metal. **(See figures 4 and 5.)**

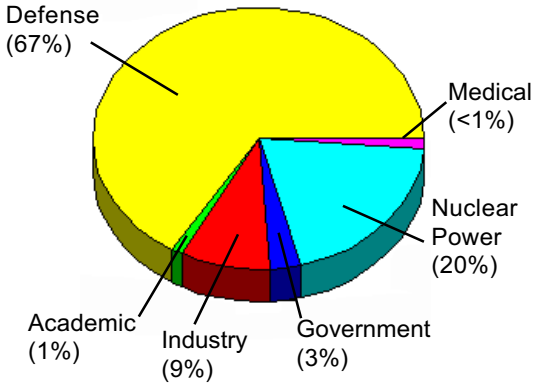

Figure 4. Sources of Low-Level Waste. (Source: Department of Energy)

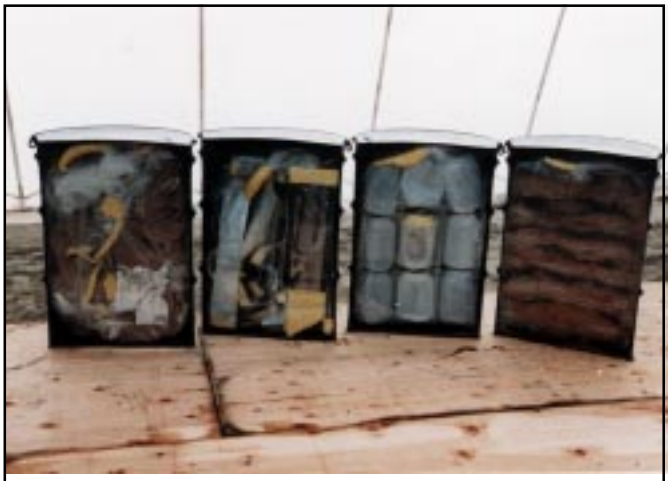

Figure 5. 55-Gallon Drums Containing Low-Level Radioactive Waste. (Source: Department of Energy)

3. What is commercial low-level waste?

Commercial low-level waste is generated as a result of activities conducted for civilian or commercial purposes. It can also include some government-generated waste, but it does not include any waste managed by the Department of Energy. The regulatory and institutional systems for managing DOE low-level waste and commercial low-level waste differ in a number of ways. See Appendix E for more background and information on commercial low-level waste management.

Other Major Categories of Radioactive Waste

High-Level Waste
High-level waste is the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that under current law require permanent isolation.

Transuranic Waste
Transuranic waste is a radioactive waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for high-level waste and spent nuclear fuel. Transuranic waste consists primarily of protective clothing, tools, glassware, equipment, soils, and sludges that have been contaminated with manmade radioactive elements heavier than uranium, such as plutonium. It is defined by law as "waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years." Most transuranic waste is a byproduct of nuclear weapons research, development, and production and the subsequent cleanup. Because of the long half-lives of some transuranic elements, transuranic waste requires the same long-term isolation as high-level waste.

Mixed Waste
Mixed waste contains both radioactive material subject to the Atomic Energy Act and chemically hazardous constituents, as defined by the Resource Conservation and Recovery Act (RCRA). RCRA defines a hazardous waste as any substance that is flammable, corrosive, reactive, or toxic. The radioactive component of mixed waste may consist of high-level, transuranic, or low-level waste. Mixed waste must be managed and disposed of in compliance with regulations for both the chemical and the radiological hazards.

Uranium Mill Tailings
Uranium mill tailings are the earthen residues, usually in the form of fine sand, that remain after the mining and processing of uranium ore. Uranium mill tailings are generated in very large volumes with low concentrations of naturally occurring radioactive materials, including thorium-232 and radium-226. Radium-226 decays to emit the radioactive gas radon-222. Most of the hazard is associated with radon emissions from piles of tailings at closed mills.

NARM/NORM
The Naturally-Occurring (NORM) and Accelerator-Produced Radioactive Materials (NARM) waste category is primarily composed of naturally occurring radioactive material including radium-226, radium-228, radon-222, and other radioactive elements that exist in Earth's crust. A small portion of NARM is accelerator waste which is mainly composed of short-lived radionuclides and is often recycled in an accelerator or used for medical purposes. DOE usually treats accelerator waste as low-level waste.

Adapted from *The Nuclear Waste Primer*, The League of Women Voters Education Fund, 1993.

4. What is mixed waste?

Mixed waste contains both radioactive and chemically hazardous constituents, as defined by the Resource Conservation and Recovery Act (RCRA). RCRA defines a hazardous waste as any substance that is flammable, corrosive, reactive, or toxic. The radioactive component of

mixed waste may consist of high-level, transuranic, or low-level waste. Mixed waste must be managed and disposed of in compliance with regulations for both the chemical and the radiological hazards. The Department of Energy (DOE) first started managing mixed low-level waste as a separate waste type in the 1980s.

An example of mixed waste generation is when a hazardous compound such as xylene is used as a cleaning solvent in a radioactive environment, and the residual solvent becomes contaminated with nuclear materials, making it both hazardous and radioactive.

5. What are contaminated environmental media?

Contaminated environmental media are naturally occurring materials such as soil, sediment, surface water, and groundwater that are radioactively contaminated with radioactive and/or hazardous materials at levels requiring further assessment to determine whether an environmental restoration action is warranted. Contaminated environmental media have resulted from intentional (e.g., atomic bomb testing or permitted discharges) and unintentional (e.g., spills and leaks) actions. After assessment, if contaminated media is excavated or removed for environmental remediation, it may then be classified as low-level or mixed low-level waste. If contaminant concentrations and risks are low, contaminated media will usually be managed in place through monitoring and containment or institutional controls.

DOE activities, primarily nuclear weapons production, have resulted in approximately 1.9 billion cubic meters of radioactively contaminated environmental media, mostly groundwater. Different management requirements and alternatives exist for contaminated water and contaminated solid media.

6. What Department of Energy activities generate low-level waste?

DOE generates low-level and mixed low-level waste from a variety of activities including

Table 1. Estimated Volume and Projected Disposition of DOE's Low-Level and Mixed Low-Level Waste

Project Disposition	Estimated Volume (in cubic meters)		Total
	Low-Level Waste	Mixed Low-Level Waste	
DOE CERCLA Disposal Cells	5,800,000	360,000	6,160,000
DOE Waste Operations Facilities	1,400,000	100,000	1,500,000
Commercial Disposal Facilities	510,000	80,000	590,000
To Be Determined	430,000*	170,000	600,000
Total	8,140,000	710,000	8,850,000

* Two DOE sites (Mound and Rocky Flats) reported that they may send a total of 100,000 cubic meters of low-level waste to either a DOE facility or a commercial facility. For the purposes of this analysis, these 100,000 cubic meters are included in the catergory of To Be Determined.

(Source: Department of Energy, Accelerating Cleanup: Paths to Closure, June 1998)

weapons production and research, nuclear reactor operations, decontamination and dismantling of nuclear facilities, basic science research, and environmental restoration. In addition, operation of the U.S. Navy's nuclear submarines and ships generates low-level waste that DOE is responsible for managing.

7. How much low-level waste must be disposed of by the Department of Energy?

DOE projects that, between 1998 and 2070, it will need to dispose of approximately 8.9 million cubic meters (m^3) of low-level waste and mixed low-level waste from both operations activities and environmental cleanup activities. **(See table 1.)** The majority of the waste will be disposed of at a facility on the site where it was generated. **(See Question H1.)** While low-level waste accounts for about 85 percent of the volume of all radioactive wastes (excluding uranium mill tailings), it accounts for only five percent of the radioactivity.

Although these projections were based on the best available information, policy and technology changes could affect subsequent projections. In addition, because the final disposition of some waste is to be determined, treatment technologies may make waste volumes larger or smaller.

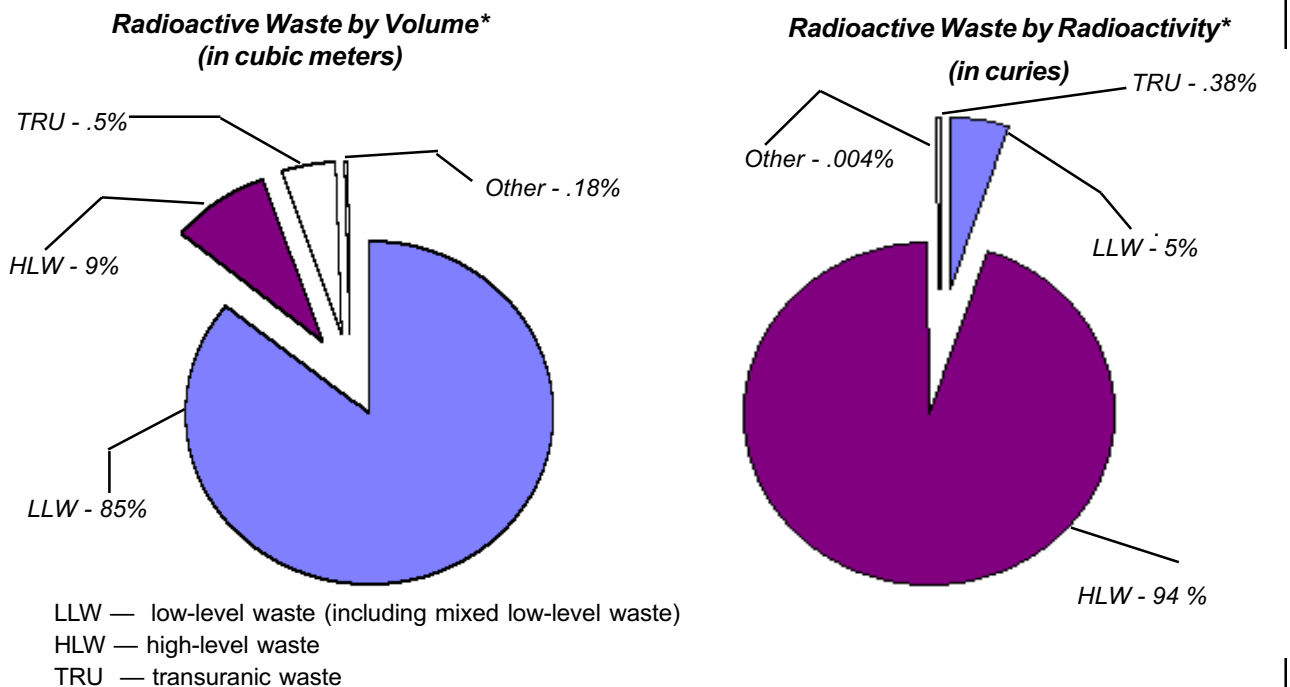

Figure 6. Distribution of DOE Radioactive Waste By Volume and Radioactivity (Source: Department of Energy, Linking Legacies, January 1997)

D. Oversight and Laws

1. What federal agencies are involved in managing low-level waste?

The primary federal agencies with responsibility for radioactive waste are the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the Department of Transportation (DOT).

- **NRC** licenses and regulates the commercial use of radioactive materials, limits the amount of radiation that people can be exposed to from nuclear power plants and from industrial and medical facilities, and establishes procedures for the safe transport of radioactive waste.

- **DOE** manages the storage, treatment, transportation, and disposal of radioactive waste generated its science research facilities, the nuclear weapons complex, and the clean up of its contaminated sites.

- **EPA** issues standards and guidance to protect people from radiation exposure, monitors radiation levels in the environment, assesses the health effects of radiation on people, and oversees and conducts cleanups of contaminated sites.

- **DOT** ensures that radioactive waste carriers comply with routing, packaging, labeling, training, documentation, and other radioactive waste transportation regulations and guidelines. (As noted in Question D6, no federal routing regulations apply to low-level waste.)

2. What roles do tribal, state, and local governments have in managing low-level waste?

Tribal, state, and local governments have responsibilities and interests regarding the management of DOE radioactive wastes within their jurisdictions. Local, state, and tribal governments play important roles in emergency response for transportation incidents, treatment and disposal facility siting decisions, reporting, monitoring, and general oversight of facilities within their jurisdictions. **(See sidebar: *Joint DOE/State of Nevada Oversight of the Low-Level Waste Program at the Nevada Test Site*.)** State governments who have been delegated RCRA authority by EPA issue permits for and inspect the operations of mixed low-level waste treatment and disposal facilities. States also enforce federal as well as state regulations governing the transportation of low-level waste. Tribal governments are involved in protecting or cleaning up and preserving access to cultural and religious resources that may be affected by radioactive waste.

Under the Low-Level Radioactive Waste Policy Act of 1980, amended in 1985, state governments are responsible for providing disposal capacity for commercial low-level waste generated within their borders. **(See Appendix E: *Commercial Low-Level Waste*.)**

Joint DOE/State of Nevada Oversight of the Low-Level Waste Program at the Nevada Test Site

The Department of Energy and the State of Nevada negotiated a unique state oversight role for ongoing low-level waste management operations at the Nevada Test Site (NTS). NTS occupies an area larger than Rhode Island – 1375 square miles – in southern Nevada, 65 miles from Las Vegas. Although atomic testing ended at the site in 1992, it still has several missions, including research and development, emergency response training, and waste management.

In 1996, Nevada Governor Bob Miller wrote to DOE Assistant Secretary Al Alm to express concern that the Department's plan to accelerate clean up of the nuclear weapons complex, which would result in increased waste disposal at NTS. The state objected, fearing southern Nevada would become the disposal destination for all types of radioactive wastes – a designation believed at odds with the most rapidly growing population in the country and a tourism–based economy. The governor proposed joint federal/state regulatory oversight of the NTS waste disposal program.

Although DOE determined that it had no legal authority under the Atomic Energy Act to delegate its regulatory authority to the state, the Department welcomed a "partnership." Under their agreement (see http://colorado.state.nv.us/ndep/boff/llwaip.htm) DOE provides information, site access, and training to staff from the state and formally responds to issues that the state raises. Nevada reviews, evaluates, and advises on environment, safety, and health procedures for the NTS waste disposal operations.

Nevada DEP also participates with DOE in waste audits that assess how well generator sites are characterizing their waste to meet the NTS waste acceptance criteria. (**See Question G3.**)

3. What are the major federal laws governing low-level waste management?

There are several federal statutes that govern the management of low-level waste, including:

Atomic Energy Act
The Atomic Energy Act of 1954 (AEA), as amended, establishes roles and responsibilities of the Nuclear Regulatory Commission, the Department of Energy, and the Environmental Protection Agency to assure the proper management of radioactive materials. The AEA is the authorizing act under which DOE regulates the treatment, storage, and disposal of low-level waste from its operations. The department has issued a number of DOE Orders (internal policy directives) and regulations to protect public health and the environment from radioactive materials. DOE Order 435.1 is the department's Waste Management Order.

National Environmental Policy Act
The National Environmental Policy Act of 1969 (NEPA), as amended, requires that all federal agencies take into account in their early planning stages the environmental effects of major policies and actions. The review process must actively involve public participation. If there is potential for significant impact, the agency must prepare an environmental impact statement. ***(*See sidebar: *DOE Makes Waste Management Decisions Under NEPA.)***

DOE Makes Waste Management Decisions Under NEPA

In February 2000, after several years of evaluating various alternatives and public input, DOE announced its policy for treating and disposing of low-level waste from operations activities. DOE's decision was based on analysis required by the National Environmental Policy Act (NEPA). Under NEPA, DOE was required to prepare an environmental impact statement (EIS), which evaluated the environmental effects of management and siting alternatives for the treatment and disposal of low-level waste and mixed low-level waste.

DOE published its *Final Waste Management Programmatic Environmental Impact Statement* (WMPEIS) in May 1997.[1] The factors used to evaluate disposal alternatives included cost, cumulative impact, environmental impact, human health risk, implementation flexibility, regulatory compliance and risk, transportation, DOE mission, and economic dislocation. Variation in the size and physical characteristics of the sites and the type and design of the disposal facilities limit the quantities and types of wastes the facilities can dispose of.

Under the decision, DOE will use six DOE facilities for low-level waste disposal, all of which have existing disposal facilities. They are:

- Hanford Site in Washington
- Idaho National Engineering and Environmental Laboratory (INEEL)
- Los Alamos National Laboratory in New Mexico (LANL)
- Nevada Test Site (NTS)
- Oak Ridge Reservation in Tennessee (ORR)
- Savannah River Site in South Carolina (SRS)

DOE plans to continue to use each of these facilities to dispose of low-level waste generated on-site. In addition, Hanford and Nevada Test Site disposal facilities would dispose of low-level waste from other DOE sites and dispose of mixed low-level waste generated on-site and at other DOE sites.

Under the WMPEIS decision, each site will perform minimum treatment (the least amount of treatment required to allow on-site disposal or transportation to another site for disposal) on low-level waste and may perform additional treatment as would be useful to decrease overall costs. DOE will treat mixed low-level waste at Hanford, INEEL, ORR, and SRS, or on-site where it is generated, in accordance with individual site treatment plans negotiated with state or federal environmental officials under the Federal Facility Compliance Act.

[1] *DOE's policy from the Waste Management Programmatic Environmental Impact Statement (WMPEIS) addresses operations waste (generally waste from previous operations and current activities) and not environmental restoration waste (generally waste from clean-up activities under CERCLA).*

DOE Assesses Its Low-Level Waste Management

Congress established the Defense Nuclear Facilities Safety Board (DNFSB) in 1989 as an independent federal agency to oversee DOE nuclear activities. It is responsible for "independent, external oversight of all activities in DOE's nuclear weapons complex affecting nuclear health and safety." The Board is not a regulatory agency but does have the authority to review and analyze facility and system designs, operations, practices, and events, and to make recommendations to the Secretary of Energy to ensure adequate protection of public health and safety, including worker safety.

By early 2000, the Board had issued 38 sets of safety recommendations, and none had been rejected. A set of recommendations in 1994 specifically addressed low-level waste. It called for DOE to conduct a comprehensive complex-wide review of its low-level waste management in order to identify problems and corrective actions.

DOE's review, titled "Complex-Wide Review of DOE's Low-Level Waste Management Environmental Safety & Health Vulnerabilities," was completed in 1996. It identified site-specific and complex-wide vulnerabilities – conditions that could lead to unnecessary radiation exposure for the workers, the public, or the environment. None were identified as high or immediate risk. The complex-wide vulnerabilities included:

- ineffective characterization of low-level waste
- inadequate storage conditions for low-level waste
- unapproved performance assessments that lacked adequate requirements.

DOE headquarters and sites prepared corrective action plans for the issues. All of the actions were completed by July 1999.

In addition, DOE Order 435.1 requires DOE low-level disposal facility operators to prepare two types of radiological assessments – Performance Assessments (PAs) and Composite Analyses (CAs). These assessments are intended to provide reasonable assurances that disposal facilities are operated in a manner that is protective of workers, the public, and the environment.

PAs are analyses of low-level waste disposal facilities designed to demonstrate there is a reasonable expectation that the long-term performance objectives for a disposal facility will be satisfied (i.e., will protect the public over time). CAs are analyses of the potential offsite impacts of a low-level waste facility in combination with other radioactive materials in the ground that may interact with the facility. DOE is responsible for reviewing and approving these assessments.

In 1997, DOE established the Low-Level Waste Disposal Facility Federal Review Group for develop and implement a review process for the PAs and CAs and determining compliance with performance objectives and measures.

In addition to the Complex-Wide Review, DNFSB Recommendation 94-2 called for DOE to complete the PAs. All of the PAs have been completed, reviewed by the Federal Review Group, and approved by DOE.

Based on its review of DOE actions the DNFSB officially closed out the recommendation in November 1999.

Comprehensive Environmental Response, Compensation, and Liability Act
The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), also known as Superfund, addresses cleanup of inactive waste sites contaminated with hazardous or radioactive substances and emergency response for hazardous substances released into the environment. The 1986 Superfund Amendments and Reauthorization Act made explicit that CERCLA covers the cleanup of federal facilities. The CERCLA process includes public participation in decisions regarding disposal of low-level waste from cleanup actions.

Resource Conservation and Recovery Act
The Resource Conservation and Recovery Act of 1976 (RCRA), which is administered by EPA or EPA-authorized states, was enacted to prevent and address environmental contamination from disposal of hazardous and solid waste. The non-radioactive hazardous constituents of mixed waste are subject to RCRA rules. To receive a RCRA permit to operate a facility that treats, stores, disposes of, or generates a hazardous or mixed waste, an applicant must describe the facility's procedures and agree to take corrective action to prevent or address the release of hazardous materials into the environment.

Federal Facility Compliance Act
The Federal Facility Compliance Act of 1992 (FFCA) amended RCRA to authorize EPA, states with EPA-authorized RCRA programs, and courts to impose punitive sanctions, if warranted, on DOE facilities. RCRA had originally given federal facilities immunity from penalties for RCRA violations. The FFCA also requires DOE to develop site treatment plans for mixed wastes.

Hazardous Materials Transportation Act
The Hazardous Materials Transportation Act of 1975 (HMTA) makes DOT responsible for protecting people and property from risks related to transportation of hazardous materials, including radioactive materials. Under HMTA highway routing regulations for radioactive materials, carriers can set their own routes for wastes that present relatively low risk when properly packaged, as long as the routes minimize radiological risk. For more radioactive materials, carriers must use "preferred routes," which are interstate highways and, when available, bypasses and beltways around cities.

Clean Air Act
The Clean Air Act (CAA) authorizes EPA to set emissions standards for hazardous and radioactive air pollutants at various facilities, including those used for low-level waste disposal. In 1989, EPA issued emissions standards for low-level waste disposal facilities.

Clean Water Act
The Clean Water Act (CWA) prohibits the discharge of pollutants, including radioactive pollutants, into U.S. navigable waters without a permit from EPA or a state with delegated authority.

4. Is there any independent oversight of Department of Energy low-level waste management facilities?

The degree of independent oversight of a waste management facility depends on the waste type and origin. For management of low-level waste from ongoing operations, DOE regulates itself and its contractors through a system of orders, with the Defense Nuclear Facilities Safety Board (DNFSB) providing some independent oversight. **(See sidebar: *DOE Assesses Its Low-Level Waste Management*.)** The treatment and disposal of mixed low-level waste from operations activities are regulated by EPA or delegated states under the RCRA. EPA regulates the treatment and disposal of low-level waste and mixed low-level waste generated from cleanup activities, generally under the CERCLA and sometimes under RCRA.

E. Transportation Issues

1. How many shipments of low-level waste have been/will be made by the Department of Energy?

DOE makes thousands of shipments to low-level waste disposal sites in the United States each year, most by truck. The number of DOE shipments of low-level waste is expected to rise over the next five years and peak at about 6,000 shipments per year between 2001 and 2006. **(See figures 6 and 7.)** DOE low-level waste shipments make up about one-half of one percent of all hazardous materials shipments each year in the United States. DOE's efforts to dispose of as much low-level waste as possible at the site where it is generated are intended to limit the number of waste shipments and associated transportation risks.

DOE Transportation External Coordination Working Group

DOE established the Transportation External Coordination Working Group (TEC/WG) in an effort to improve interactions between DOE and external groups interested in the department's transportation activities. TEC/WG members include organizations such as the National Association of Counties and the National Emergency Management Association whose members have an interest in radioactive waste transportation. **(See Appendix F.)** They meet twice a year to learn about DOE's transportation activities, to discuss concerns, and to provide suggestions on ways DOE can address those concerns.

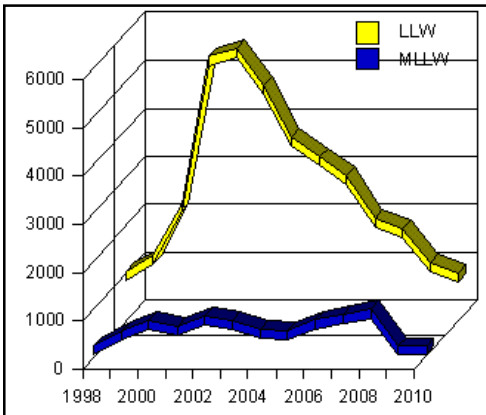

Figure 6. U.S. Department of Energy Low-Level and Mixed Low-Level Waste Projected Number of Shipments through 2010.(Source: Department of Energy)

2. Who regulates the shipment of low-level waste?

Federal and state agencies regulate various aspects of the shipment of low-level waste.

Federal Agencies. At the federal level, highway transportation of low-level waste is regulated by Department of transportation (DOT) and Nuclear Regulatory Commission (NRC).

DOT regulations for transportation of radioactive materials are part of a larger DOT system for regulating all hazardous materials. Radioactive materials are one of several categories of hazardous materials regulated by DOT under the Hazardous Materials Transportation Act (HMTA). DOT regulations cover all aspects of transportation, including packaging, shipper and carrier responsibilities, and documentation for all levels of radioactive material from exempt quantities to very high levels. **(See Questions E4 and E5.)**

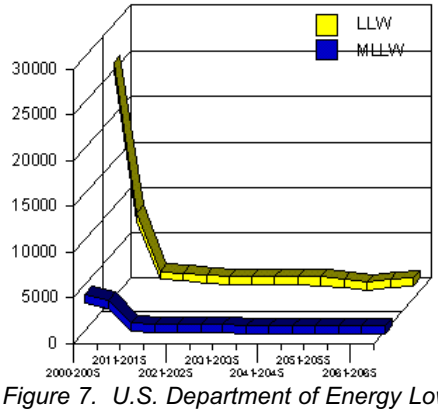

Figure 7. U.S. Department of Energy Low-Level and Mixed Low-Level Waste Projected Number of Shipments through 2070. (Source: Department of Energy)

NRC regulations primarily address special packaging requirements for more highly radioactive materials such as shipments of Celium Capsules. **(See Question E5.)** DOT and NRC regulations are based on international safety standards set by the International Atomic Energy Agency.

State Agencies. Some states have enacted regulations for transportation of low-level waste. State regulations typically address issues such as permitting, notification, determination of routes, financial liability, and inspection. States also enforce the federal regulations. Almost all states conduct roadside inspections that follow DOT requirements. Many states require transportation permits for radioactive materials. For a listing of state regulations, see http://www.trex-center.org.

3. How is low-level waste transported?

Most low-level waste is transported by truck, typically tractor-trailer trucks in containers specifically designed to prevent hazards. **(See Question E5.)** Some shipments are made by train or a combination of truck and train. While safety is a primary consideration, other factors, including availability of rail infrastructure to disposal facilities, costs, and DOE program needs, are also considered in transportation decisions. **(See figures 8 and 9.)**

Figure 8. Low-level waste being prepared for shipment. (Source: Department of Energy)

Figure 9. Low-level waste shipment. (Source: Department of Energy)

4. What regulations must shippers follow?

Shippers, packagers, and carriers of all hazardous materials, including radioactive materials, are responsible for complying with federal regulations for packaging, identifying materials, labeling packages and vehicles, driver training, documentation, and reporting any incidents involving accidental releases. The regulations apply to all non-national security shipments by DOE and its contractors. **(See sidebar: *DOE Transportation Protocols*.)**

DOE Transportation Protocols

Concerns expressed by state and tribal governments and other stakeholders prompted DOE to review its shipping practices in 1998.

DOE's operating programs currently use a number of different protocols and practices for shipping radioactive materials and wastes. These differences derive, in part, from the broad range of hazards associated with different types of materials and wastes. For example, spent nuclear fuel and high-level waste shipments require different handling than low-level radioactive waste shipments. While DOE has a good record of safe shipments, stakeholders expressed concern about the lack of uniformity in shipping protocols and practices and the lack of communication on the reasons for the differences.

The goal of DOE's transportation protocol initiative is to "address concerns and evaluate and standardize DOE radioactive material transportation practices where appropriate." DOE is working with a diverse group of interested parties to develop protocols, primarily through a subset of participants on DOE's Transportation External Coordination Working Group (TEC/WG). **(See sidebar: *DOE Transportation External Coordination Working Group.)***

The initiative is intended to improve coordination and efficiency in transporting DOE radioactive materials and waste and to improve communication and understanding between DOE and other federal agencies, state, tribal and local governments, and other stakeholders. DOE expects to complete the new protocols by early in 2001.

They include:

- Shipment pre-notification
- Projected shipment planning information
- Routing
- Emergency notification
- Safe parking
- Carrier/driver requirements
- Tracking
- Inspections
- Transportation planning
- Security
- Emergency planning
- Emergency response
- Recovery and cleanup
- Transportation operation contingencies

❖ **Packaging — (See Question E5.)**

❖ **Identifying materials** — For *transportation regulation* purposes, regardless of the quantity, any material which has a specific activity greater than 0.002 microcuries per gram is considered radioactive material. Specific activity refers to the activity per unit mass of the material (i.e., the concentration). These materials are classified as fissile, special form, normal form, low specific activity, or highway route-controlled quantities. The classification of the material determines the kind of packages used for shipping. **(See Question E5.)**

Most DOE low-level waste is classified as low specific activity. Low specific activity materials are radioactive materials that are uniformly dispersed throughout a substance, such as contaminated soil or debris, to such an extent that it poses little hazard even if released in an accident. While the concentration (curies per gram) must be less than specified concentration

Figure 10: Packaging Labels (Source: Department of Energy)

limits, the total amount of material, and thus the total radioactivity, may be quite high.

❖ **Labeling packages** — Labels on packages of radioactive material indicate the type of hazard contained in a package. Although the package required for transporting radioactive material is based on the quantity of activity inside the package, the label required on the package is based on the radiation hazard outside the package. There are three possible labels depending on the radiation levels at the surface and at one meter from the surface. The three labels are commonly called *White 1*, *Yellow 2*, and *Yellow 3*, referring to the color of the label and the numeral displayed. (**See figure 10**.)

Labels are required if the radiation at the surface and at one meter meet the following criteria:

Label	Surface Radiation Level		Radiation Level at 1 Meter
White 1	Does not exceed 0.5 mrem/hr		Not applicable
Yellow 2	Does not exceed 50 mrem/hr	AND	Does not exceed 1 mrem/hr
Yellow 3	Exceeds 50 mrem/hr	OR	Exceeds 1 mrem/hr

❖ **Placarding (Labeling vehicles)** — Trucks and rail cars carrying low-level waste are required to have large diamond-shaped "RADIOACTIVE" placards on the outside of the vehicle if they meet one of two criteria: 1) they contain low specific activity material shipped as exclusive use; or 2) they are carrying packages with Yellow 3 labels. Some shipments with very low amounts of radioac tivity with White 1 or Yellow 2 labels are not required to display the placard, but still must have labels on each package of waste inside the vehicle. **(See figure 11.)**

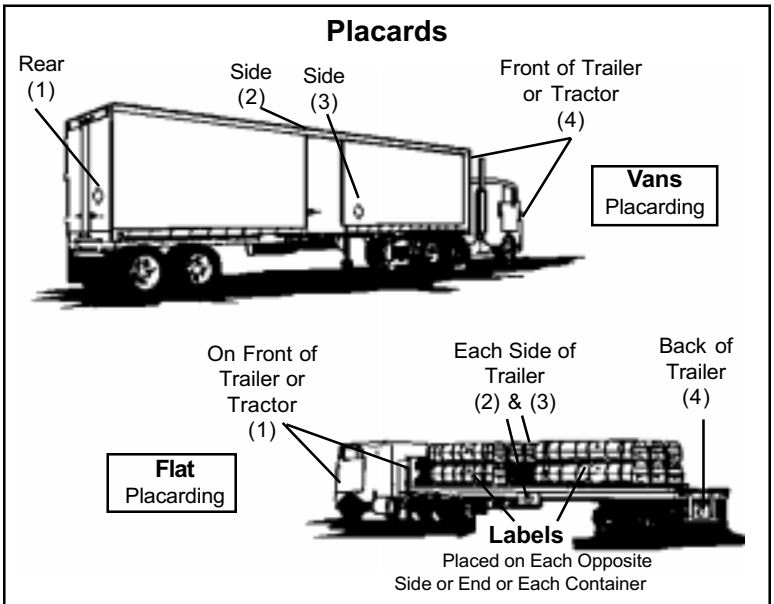

Figure 11. Vehicle Labels
(Source: U.S. Nuclear Regulatory Commission)

- **Training** — Drivers of all hazardous materials, including low-level waste, must be trained in DOT regulations and protocols. Most radioactive waste shipments require specific driver training on routing and emergency response appropriate for the materials they are carrying.

- **Documentation** — All carriers of low-level waste must have shipping papers that clearly specify what is being transported. **(See also Question E7.)**

5. What kinds of containers/packaging are used for shipping low-level waste?

DOT and NRC set regulations for packages that carry low-level waste. The type of package required depends on the total quantity of radioactivity, the form of the materials, and the concentration of radioactivity. All packages used to transport radioactive materials must meet certain general requirements (e.g., can be easily handled and all valves must be protected from unauthorized operation). Often the package used for transport is also used for disposal.

Summary of Communication Before and During LLW Shipments

- **Prior to shipment** – DOE conducts informal communications with the affected communities. The extent of communications and information depends on such factors as community interest and relative level of risk. No formal notifications are required to states or the public. The receiving site is notified of the schedule.

- **During shipment** – Typically there is no communication with the DOE shipping or receiving site. Carriers (DOE contractors) typically maintain communications with their corporate dispatch centers.

- **In the event of an incident** – The carrier would notify local emergency response officials, its dispatch center, and the DOE shipper. Local or state officials would assume incident command. DOE may send out a Radiological Assistance team, as necessary.

- **Upon receipt of shipment** – The carrier notifies its dispatch center of its arrival and the dispatch center notifies the DOE shipper.

(Adapted from fact sheet for 1999 DOE Site-Specific Advisory Boards Transportation Workshop developed by Phoenix Environmental.)

The basic types of packages used for transporting radioactive materials are summarized below. Most low-level waste is shipped in Industrial or Type A packages.

Types of Transportation Packages

Package Type	Materials Transported	Design	Testing Requirements
Excepted 	Materials with extremely low levels of radioactivity, such as instruments or items like smoke detectors.	Must meet general design requirements. Packages are made of such things as fiberboard or sturdy wooden or steel crates.	General requirements include ease of handling, type of materials allowed, and other safety-related features.
Strong-Tight*	Materials with low levels of radioactivity, such as natural uranium and rubble from decommissioning of nuclear reactors.	Designed to withstand normal handling and stresses.	Package must: ◆ Be leak free ◆ Be securely closed ◆ Have sufficient cushioning/ absorbency
Industrial (IP)* 	Materials with low amounts of radioactivity which present limited hazard such as contaminated equipment and waste solidified in concrete or glass.	Must meet general design requirements plus requirements relating to normal transport and minor mishap conditions. There are three categories based on package strength: IP-1, IP-2, IP-3	**IP-1:** must meet same requirements as excepted packaging **IP-2:** must withstand a free drop to flat, hard surface and compression of at least 5 times its weight **IP-3:** must meet all tests required for Type A packages
Type A 	Materials with higher concentrations or amounts of radioactivity than for excepted or IP.	Designed to withstand normal transport and minor mishap conditions. Consist of inner containment vessel of glass, plastic or metal, surrounded by an outer container of polyethylene, rubber, wood, or metal.	Must withstand: ◆ Water spray for 1 hour ◆ Penetration by dropping 13.2 pound bar on the package ◆ Vibration for 1 hour ◆ Compression of at least 5 times its weight ◆ Free-drop on a flat, hard surface
Type B 	Materials with high radioactivity levels including spent nuclear fuel and high-level waste.	Designed to withstand normal transport and severe accident conditions. Packaging designs are certified by the NRC.	In addition to Type A requirements, must withstand: ◆ Free-drop of 30 feet ◆ Puncture test (dropping package onto a steel rod) ◆ Crush test ◆ Exposure to 1,475° F ◆ Immersion in 50 feet of water

[Adapted from fact sheet prepared for 1999 DOE Site-Specific Advisory Boards Transportation Workshop by Phoenix Environmental.]

*Strong-tight packages are currently being phased out and replaced with industrial packages (IP).

DOE is responsible for determining the appropriate packaging for its waste and ensuring that each package containing radioactive materials meets DOT and NRC requirements for design, materials, manufacturing methods, minimum thickness, tolerance, and testing. Containers must be marked to indicate that all requirements have been met. Type B packages must receive a Certificate of Compliance from NRC.

6. What shipping routes are used? How are they chosen?

In general, the carrier (DOE contractor) selects the shipping routes for highway shipments of low-level waste in accordance with DOT regulations and in cooperation with DOE, states, and tribes. There are no specific federal requirements for selecting shipping routes for low-level waste. However, DOE selects routes to minimize radiological risk with consideration to such factors as accident rates, time in transit, population density, time of day, and day of the week.

In some cases a state agency may designate specific routes after conducting a routing analysis and receiving approval from the Federal Highway Administration.

7. How are shipments tracked and monitored?

Federal regulations require that every shipment of low-level waste be tracked through shipping papers (bill of lading or manifest). Shippers must give a copy of the shipment manifest to the disposal facility operator and must receive an acknowledgment that the facility received the waste. If the shipper does not receive acknowledgment within one week of shipment, it must begin an investigation.

Although there are no specific requirements for ongoing or periodic communication during shipment, carriers are typically in communication with their dispatch centers as required by company procedure. **(See sidebar: *Summary of Communication Before and During Shipments*.)**

In addition, states establish regulations and procedures for inspections following DOT regulations, and programs vary from state to state.

8. How much radiation exposure would people traveling near a shipment vehicle receive?

The maximum allowable radiation exposure at two meters (about six feet) from a transport vehicle is 10 millirems per hour. At that level, a person would have to stand next to a vehicle for six minutes before he/she would receive even one millirem of radiation exposure – roughly equal to an individual's average daily exposure from natural background radiation. Most shipments of radioactive materials are significantly below the maximum allowable limit, and radiation exposure would be much less.

9. How can I find out if low-level waste is being shipped through my community?

DOE does not give formal notification to state, tribal, or local governments for routine low-level waste shipments, although some DOE field offices may have informal agreements about notification. Maps and information about previous DOE radioactive materials shipments and the routes used are available at DOE's National Transportation Program Web site at http://www.ntp.doe.gov/.

State agencies responsible for emergency management or for licensing, permitting, and inspecting vehicles carrying radioactive materials may be able to provide information. A list of contacts is available at http://trex-center.org and http://www.gpieng.com/ioc/userguide.html.

Local Emergency Planning Committees or State Emergency Response Commissions, which usually include representatives of local fire departments, may also have information. A list of contacts is available on EPA's Web site at http://www.epa.gov/ceppo/sta-loc.htm.

F. Emergency Response to Low-Level Waste Transportation Incidents

1. How many transportation accidents have involved low-level waste? Were people exposed to radiation?

Between 1971 and 1999, there were 62 transportation accidents involving the transport of low-level radioactive waste (both DOE and commercial) in the United States. Of these 62 accidents, only four resulted in the release of radioactive materials. The radioactive material was quickly cleaned up and repackaged with no measurable radiation exposure to people along the routes or to the emergency response personnel.

2. Who is responsible for responding to radiological transportation accidents?

Local, state, tribal, and federal governments and carriers all have responsibility for preparing for and responding to radiological emergencies from low-level waste transportation. DOE provides guidance and assistance to these agencies.

Local/Tribal Emergency Services Personnel. Local or tribal government personnel typically are first responders and incident commanders for an offsite transportation accident. Although many local jurisdictions have special hazardous materials response units, most seek state or federal technical assistance during radiological incidents.

State and Tribal Government Officials. State and tribal governments have primary responsibility for the health and welfare of their citizens and therefore have an interest in ensuring the safety of shipments of hazardous materials, including DOE-owned materials, within their boundaries. Some states maintain specialized emergency response units capable of responding to radioactive materials incidents in support of local authorities. However, few tribal governments possess capabilities beyond that of first responders and may request additional assistance of DOE.

Federal Emergency Management Agency. The federal government's emergency response activities are coordinated by the Federal Emergency Management Agency (FEMA) through a Federal Radiological Emergency Response Plan developed by FEMA and 11 other federal agencies. FEMA also provides assistance and evaluates state and local preparedness for radiological emergencies.

U.S. Department of Transportation. DOT has established requirements for reporting transportation accidents involving radioactive materials and has a comprehensive training program on handling emergencies involving radioactive materials shipment. The U.S. Coast Guard operates the National Response Center, a central federal reporting center for releases of hazardous substances.

U.S. Department of Energy. DOE operates a Radiological Assistance Program (RAP), with eight regional offices staffed with experts available for immediate assistance in offsite radiological monitoring and assessment. DOE RAP teams assist state, local, and tribal officials with identification of the material, monitoring to determine if there is a release, and general support. **(See figures 12 and 13.)**

Figure 12. U.S. Department of Energy Radiological Assistance Program (Source: Department of Energy)

Department of Energy as a Shipper. Like private-sector shippers, DOE must provide emergency response information required on shipping papers, including a twenty-four hour emergency telephone number. Shippers have overall responsibility for providing adequate technical assistance for emergency response should the carrier fail to do so.

Carriers. Carriers are required to provide emergency planning, emergency response assistance, liability coverage, and site cleanup and restoration. With regard to DOE carriers, it is the policy of DOE to respond to requests for technical advice with appropriate information or resources.

Figure 13. U.S. Department of Energy Radiological Assistance Program team members during an exercise (Source: Department of Energy)

3. How are accidents reported?

Federal law requires that responsible parties notify the National Response Center of all releases of hazardous substances, including radioactive materials, that exceed "reportable" quantities – or levels of concern.

Transportation accidents involving hazardous materials must be reported to the National Response Center immediately by the carrier when, as a direct result of the materials:

- A person is killed;
- A person receives injuries requiring hospitalization;
- Property damage exceeds $50,000; or
- Fire, breakage, or spillage of a disease-causing agent occurs.

A Look at the Response to a Transportation Incident

Local, state, tribal, and federal governments and carriers work together to be prepared for and respond to transportation incidents involving radioactive materials shipments. The following incident summary illustrates the typical sequence of events and players involved in responding to and following up on an incident.

Several factors contributed to a December 15, 1997, incident involving a truck containing seven containers of low-level radioactive waste. The shipment was on its way from the Fernald Environmental Management Project site in southwestern Ohio traveling on to the Nevada Test Site for disposal.

The basic sequence of response actions went as follows:

- As the driver exited from Interstate Highway 40 near Kingman, Arizona, he observed that the trailer was leaking, and at approximately 5:00 p.m. he notified the Assistant Emergency Duty Officer at Fernald Environmental Management Project and his company of the leak.
- The company then notified the EPA National Response Center and the Arizona Radiological Regulatory Agency.
- The Kingman Fire Department arrived at the scene within 20 minutes of being notified by the County Sheriff and within an hour of when Fernald first received notice.
- Fernald initiated an Emergency Operations Center within 10 minutes, which was operational within an hour.
- DOE dispatched a Radiological Assistance Program (RAP) Team. The RAP Team arrived approximately six hours after first notice of the leak.
- DOE also dispatched a team from the Fernald Environmental Management Project to support the incident command team. The Fernald team arrived on the scene at 5:30 a.m. the next morning.
- At approximately 1:00 p.m. the day after the accident, the responders determined that there was no radiological hazard and that the leaking liquid was not hazardous to the health and safety of the public or damaging to the environment.
- The Fernald Environmental Management Project Support Team then took custody of the shipment, controlled the leaks, and returned the low-level radioactive waste to Fernald on December 21, 1997.

As a result of the incident and four other leaking containers discovered upon arrival at the Nevada Test Site, on December 29, 1997, DOE suspended use of the “suspect” white metal containers and suspended shipments from the Fernald site to the Nevada Test site, pending review. DOE also established an independent review to determine if similar containers already placed in Nevada Test Site disposal facilities presented potential problems.

In addition, any transportation incident that involves the unintentional release of radioactive materials must be reported to DOT within 15 days of the incident. **(See sidebar: *A Look at the Response to a Transportation Incident*.)**

4. How can I find out if my community is prepared to respond if there is an accident involving low-level waste?

You can find out about local emergency preparedness by contacting your Local Emergency Planning Committee (LEPC) or State Emergency Response Commission. The LEPC is responsible for coordinating efforts to prepare for response to incidents involving hazardous materials in the community. A list of contacts is available on EPA's Web site at http://www.epa.gov/ceppo/sta-loc.htm.

G. Waste Storage and Treatment

1. How is low-level waste managed?

Low-level waste and mixed low-level waste are generally stored until they can be treated if necessary, shipped if necessary, and disposed of. In some cases, waste must be stored for long periods while waiting for the availability of appropriate treatment facilities or better treatment processes. Some radioactive wastes is placed in long-term storage to allow the radioactivity to decay to a safe level. DOE's preference is to dispose of low-level and mixed low-level waste on-site where it is generated, but waste may also be shipped off-site to either another DOE or a commercial facility.

2. How and where is low-level waste stored?

The methods used for storing low-level waste and mixed low-level waste depend on the chemical and physical characteristics of the waste, and the type and concentration of radionuclides. Typically, low-level waste is stored at the site where it is generated until it is treated and/or disposed of. Waste is usually placed into appropriate containers, such as metal drums, or metal or plywood boxes for storage.

Mixed low-level waste poses more of a challenge in terms of storage because of state and federal regulatory requirements under the Resource, Conservation and Recovery Act (RCRA) which prohibit the storage of untreated waste except to facilitate proper recovery, treatment, or disposal. In accordance with the Federal Facility Compliance Act of 1992, DOE has worked with state and federal regulators to develop plans for treating mixed low-level waste, which allow the department to store it for longer periods of time, in anticipation of treatment. Mixed low-level waste is stored at the site where it is generated until it is treated either at a DOE facility or a commercial facility.

3. What is waste treatment?

Waste treatment is the use of technologies to change the physical, chemical, or biological characteristics of the waste to reduce its volume and/or toxicity and to make the waste safer for disposal.

Figure 14. Compaction waste treatment .
(Source: Department of Energy)

4. How is low-level waste treated before disposal?

Low-level waste and mixed low-level waste are treated based upon the composition, quantity, and form of the waste material. DOE sites usually

perform at least minimum treatment, which consists of basic handling, packaging, and solidification of liquid and fine particulate low-level waste that will allow the waste to be disposed of on-site or transported to another site for disposal. About half of the low-level waste generated is treated by volume reduction technology, such as compaction, shredding, or incineration. **(See figure 14.)** Volume reduction typically occurs on-site, although some sites do use commercial treatment facilities.

Approximately 40 percent of mixed low-level waste undergoes thermal treatment, primarily incineration, and 60 percent of the waste undergoes non-thermal treatment, including macroencapsulation. Mixed low-level waste is incinerated at DOE and commercial treatment facilities. The only active DOE incinerator is at Oak Ridge Reservation. It may close in 2003, depending on demand, cost, and the reliability of commercial alternatives. Macroencapsulation is generally accomplished at off-site commercial treatment facilities, although some is done on-site at Hanford, INEEL, and Savannah River Site (SRS). INEEL also offers macroencapsulation service to other DOE sites.

H. Waste Disposal

1. Where is low-level waste disposed of?

In general, DOE tries to dispose of low-level and mixed low-level waste at a disposal facility on the site where it is generated. DOE must ship some waste to another DOE site or to a commercial disposal facility. Disposal decisions are based on facility waste acceptance criteria, capacity, cost, and other factors, including transportation risks, stakeholders' willingness to accept the wastes, and regulatory agreements and milestones. In addition to disposing of low-level and mixed low-level waste, a large quantity of contaminated media is managed in place through monitoring and containment or institutional controls. **(See figures 15, 16, and 17.)**

Figure 15. DOE's Major Low-Level and Mixed Low-Level Waste-Generating Sites and Disposal Facilities (Source: General Accounting Office)

The specific disposal facility that is used depends on waste type and origin. The majority of low-level and mixed low-level waste is generated by cleanup activities conducted under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). This waste is usually disposed of at the site where it is generated in disposal facilities specifically designed for cleanup wastes, known as CERCLA disposal facilities. DOE operates CERCLA disposal facilities at the Fernald Environmental Management Project in Ohio and the Hanford Site in Washington State and plans facilities for the Idaho National Engineering and Environmental Laboratory (INEEL) the Oak Ridge Reservation (ORR) in Tennessee, and the Nevada Test Site (NTS).

Low-level waste generated from ongoing operations and cleanup waste that cannot be disposed of in a CERCLA disposal facility are disposed of at one of six DOE Waste Management disposal facilities or shipped off-site for disposal at a licensed commercial disposal facility. Because on-site disposal is not always feasible, DOE has designated the Hanford Site and NTS as regional low-level waste disposal facilities since they have excess capacity.

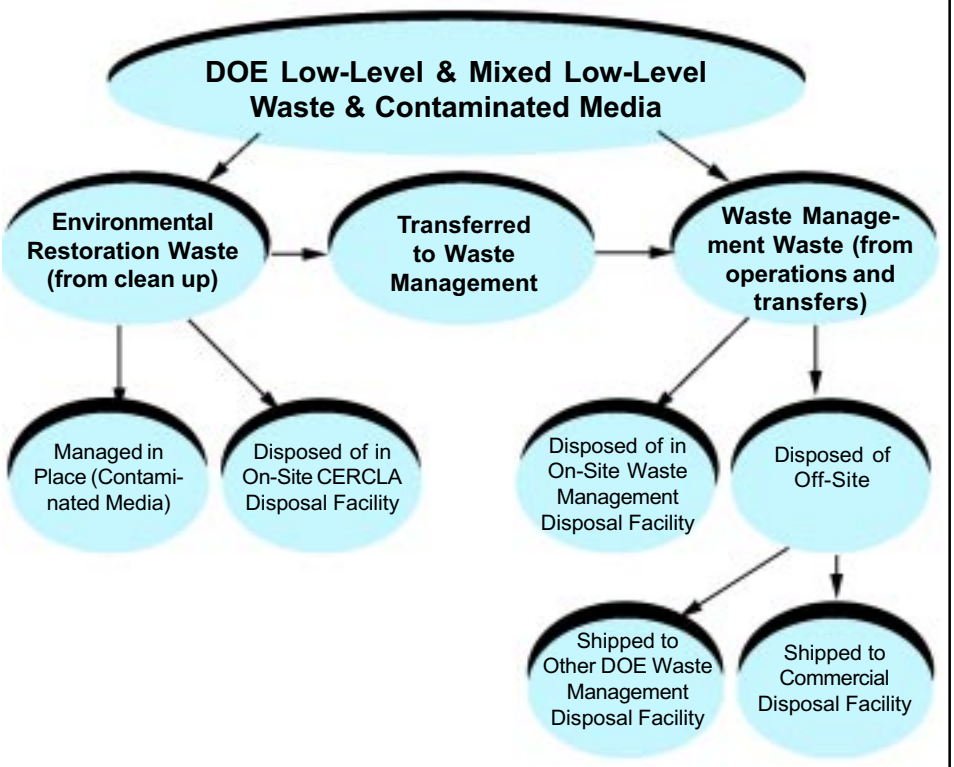

Figure 16. DOE Disposal Options for Low-Level and Mixed Low-Level Waste and Contaminated Media

The Los Alamos National Laboratory (LANL) in New Mexico, the Savannah River Site (SRS) in South Carolina, INEEL and ORR will continue to dispose of their low-level waste on-site as long as it is practicable and cost effective. In addition, INEEL, and SRS will continue to dispose of low-level waste generated by the Naval Nuclear Propulsion Program. ***(See sidebar: DOE Makes Waste Management Decisions Under NEPA, section D.)***

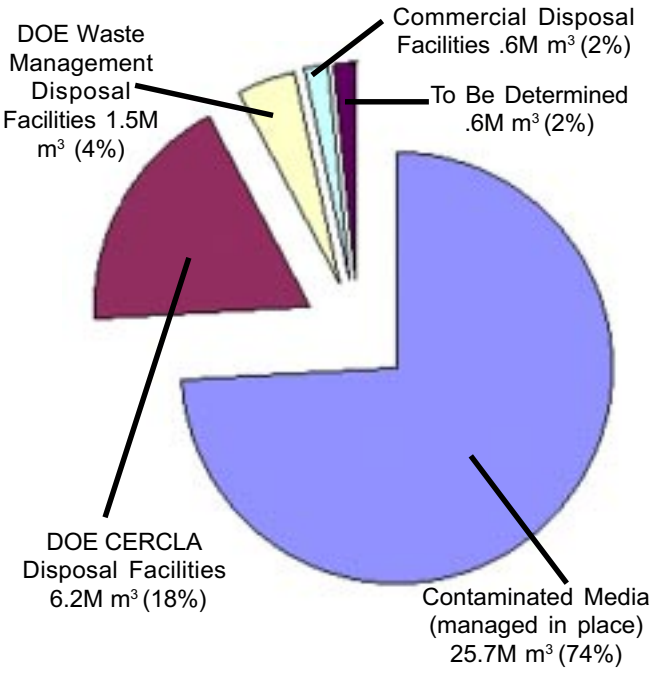

Figure 17. Estimated Volumes and Disposition of DOE Contaminated Media and Low-Level and Mixed Low-Level Wastes 1998 through 2070 (in millions of cubic meters and percentage) (Source: Department of Energy)

DOE plans to dispose of most of its mixed low-level waste at Hanford and NTS, the only DOE sites that have mixed low-level waste disposal capacity. The states of Washington and Nevada oversee the Hanford and NTS mixed low-level waste disposal facilities to ensure that they meet the requirements of the Resource Conservation and Recovery Act for disposing of the hazardous waste components of mixed waste.

2. How is low-level waste disposed of?

Before most operations waste is disposed of, it is packaged in metal or plywood boxes or sealed containers, depending on its characteristics. Once packaged, waste is disposed of in shallow land burial grounds (unlined open trenches) or above ground vaults. Shallow land burial grounds are most likely to be located in the western United States because of the arid environment where evapo-

ration exceeds precipitation. **(See figure 18.)** These disposal facilities are located high above groundwater and pose little concern about contaminants leaking into groundwater. Conversely, above ground vaults are commonly used in the eastern United States because of the rainy and humid environment, resulting in groundwater located need the land's surface. **(See figures 19 and 20.)**

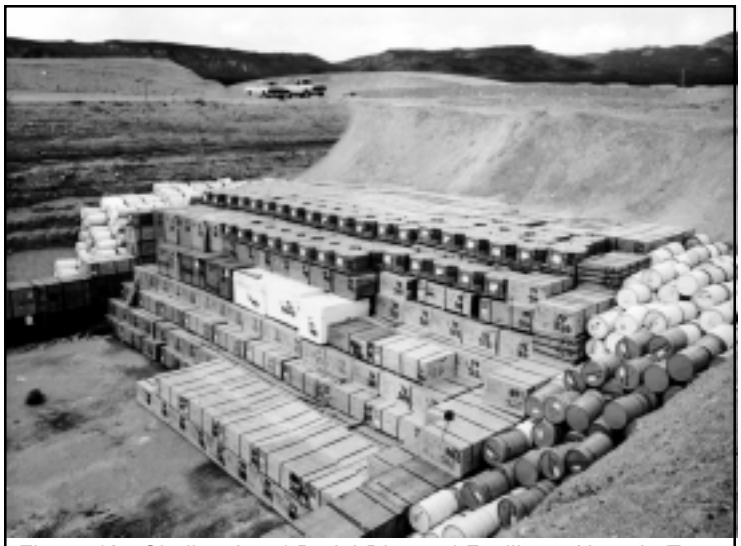

Figure 18. Shallow Land Burial Disposal Facility at Nevada Test Site (Source: Department of Energy)

Cleanup waste from environmental restoration activities under CERCLA is generally not packaged in containers before it is disposed of in specially designated above ground vaults or trenches that are lined. **(See figure 21.)** The liner, usually a geotextile material, meets the requirements for the disposal of the hazardous components of mixed low-level wastes. Contaminated media are often managed or disposed of in place.

Figure 19. Above Ground Vaults Disposal Facility at Oak Ridge Reservation (Source: Department of Energy)

3. What are waste acceptance criteria?

Waste acceptance criteria are the requirements set by individual disposal facilities for the type and condition of the waste they will accept for storage, treatment, or disposal. Waste acceptance criteria are intended to help ensure that the facility has the appropriate capacity to handle the particular type of waste and that the public, workers, and the environment are protected. These acceptance criteria address such factors as: composition of waste and containers; physical and chemical characteristics; radiological characterization; waste segregation; and treatment and/or disposal path.

4. What safeguards are used at disposal sites?

Safeguards for low-level waste disposal facilities are incorporated through siting, design, operations, monitoring, and closure to avoid or minimize the potential for radiation exposure. Facilities are designed to achieve long-term stability and to minimize the need for active maintenance following final closure of disposal sites. Geological, hydrological, and climate

Figure 20. Above Ground Vault at Savannah River Site. (Source: Department of Energy)

Figure 21. Fernald, Ohio, CERCLA Disposal Facility (Source: Department of Energy)

Figure 22. Air Monitor (Source: Department of Energy)

factors are considered in design. Some examples of operations and closure safeguards include:

- ❖ Air and groundwater are monitored regularly during and after operations, particularly during waste burial, to ensure that there is no migration of radiological contaminants. **(See figure 22.)**
- ❖ Workers receive training in properly handling radioactive and hazardous waste.
- ❖ Buffer zones or fences limit access to the disposal facilities.
- ❖ Hazard signs or markers on disposal cells help inform future generations to prevent inadvertently disturbing the radioactive waste **(See sidebar:*Long-Term Management of Department of Energy Legacy Waste Sites*.)**

5. What is the Department of Energy doing to minimize generation of this waste in the future?

The following are examples of how DOE is minimizing its waste generation:

- ❖ Reducing mixed waste by separating hazardous materials from radioactive constituents.
- ❖ Substituting nonhazardous solvents for hazardous solvent where technically practicable.
- ❖ Using waste reduction processes or equipment modifications.

Long-Term Management of Department of Energy Legacy Waste Sites

Regardless of the extent of cleanup efforts, some hazards will remain at many DOE sites for hundreds or thousands of years to come. Using currently available technology, many sites cannot be cleaned up enough to allow unrestricted use. Other sites are being used for storage and/or permanent disposal of radioactive waste, including low-level waste. DOE, along with other federal agencies such as EPA, has begun to establish a long-term stewardship program to manage the hazards at these sites for many years into the future.

According to DOE, long-term stewardship means measures that guaranteed continued protection of human health and the environment from hazards that may remain after the completion of the cleanup of weapons complex sites. The measures could involve physical controls, institutional controls, information, and other mechanisms. Stewardship can include both active controls and passive controls. Active controls include maintaining and monitoring physical barriers (e.g., caps, fences) and groundwater monitoring and treatment systems. Passive controls include such things as regulation of land use and ownership and activities to convey information (e.g., markers, government archives).

At the request of DOE, the National Academy of Sciences Committee on Remediation of Buried and Tank Wastes studied DOE's planning and development of long-term stewardship systems for DOE waste sites. A pre-publication copy of the committee's report, *Long-Term Institutional Management of U.S. Department of Energy Legacy Waste Sites*, was made available early in 2000.

The committee found that the majority of DOE controlled wastes sites — 109 out of 144 — will require long-term stewardship since these DOE sites will not be cleaned up sufficiently to allow unrestricted use.

The report argues that effective long-term stewardship will be difficult to accomplish because of technical, social, fiscal, and political limitations. It recommends that DOE develop a broader-based, more systematic method for long-term stewardship. The report identifies several concerns with DOE's current plans: the details of long-term stewardship are not yet identified; adequate funding is not assured; and there isn't sufficient evidence that stewardship measures are reliable over the long term.

In addition, long-term management will require periodic reevaluation of the waste sites that continue to pose a risk to public health and the environment to ensure that they do not fall into neglect and that new opportunities for further remediation are considered.

I. Health Risks of Radiation

1. How is human exposure to radiation measured?

In the United States, human exposure to radiation is measured in units called rem (roentgen equivalent man). The rem value takes into account both the amount, or dose, of radiation and the biological effect of the specific type of radiation. A millirem is one one-thousandth of a rem.

In the United States, the average person is exposed to about 360 millirem per year — approximately 300 millirem from natural background sources and approximately 60 millirem from manmade sources, such as medical x-rays or treatment.

2. What are the most likely sources of human exposure to ionizing radiation and specifically low-level waste?

Most of the radiation we are exposed to comes from natural sources, referred to as *background radiation*. Natural sources include the sun's rays, soil, and water, and even within our bodies. In addition, there are many manmade sources of radiation resulting from the use of radioactive materials in nuclear power plants; medical research, diagnosis, and treatment; industry and research; and nuclear weapons research and production. These activities generate low-level waste.

Regulatory guidelines for low-level waste storage, treatment, transportation, and disposal are designed to prevent exposure to radiation. Nonetheless, individuals living near the facilities or transportation routes could potentially, though not likely, be exposed to radiation from low-level waste as a result of inappropriate storage, treatment, or disposal; groundwater contamination near several disposal facilities; or transportation incidents.

3. What are the harmful effects of exposure to radiation?

Ionizing radiation is powerful enough to alter the structure of cells and cause damage to living organisms. It can cause damage to cells or cell components and in sufficient quantity can cause death. The effects of exposure depend on the type of radiation, the pathway of exposure, the affected body site, the dose, and the length of time of exposure.

Over a long period, chronic exposure to low levels of radiation may result in some increased risk of cancer, benign tumors, cataracts, and congenital defects. Extremely acute exposure, or large doses of radiation on the order of greater than 1,000 times higher than background levels, can result in death.

While the effects of exposure to high levels of radiation are fairly well understood, the effects of exposure to low levels are more difficult to detect and predict. In addition, although any exposure to radiation can be harmful, most cells have the ability to repair the damage done by background levels of radiation or very low exposure.

Reporting on Environmental Releases

Actual releases of radiation to the environment from DOE facilities are reported in annual site environment reports. The reports also include calculations of all potential liquid and airborne pathways of exposure. The reports can highlight trends or potential problems, although exposures are typically well below federal limits.

For example, the *1998 Savannah River Site Environmental Report* reported that the potential dose to a theoretical maximally exposed individual at the site boundary from liquid releases was 0.12 millirem or 0.12 percent of the 100-millirem limit for annual exposure to members of the public from all DOE sources. The potential dose from airborne releases was 0.07 millirem or 0.7 percent of the 10-millirem limit on airborne exposure from a DOE facility. The potential all-pathway dose was 0.19 percent of the 100 millirem per year limit.

The site environmental reports are available at DOE reading rooms and on Web sites for the individual DOE sites (e.g., www.srs.gov).

4. Is it safe to live near a low-level waste disposal area or transportation route?

Federal regulations place limits on exposure from sources of radiation including low-level waste, although in most cases actual exposures fall way below the limits. **(See sidebar: *Reporting on Environmental Releases*.)** The limit on exposure to members of the public from all DOE sources of radiation is 100 millirem per year. The average annual background exposure is 300 millirem per year. A similar limit applies to nuclear power plants.

For disposal sites, NRC requires that annual exposure to any member of the public not exceed 25 millirem to the whole body, 75 millirem to the thyroid, or 25 millirem to any other organ. The maximum allowable radiation exposure at about six feet from a transport vehicle is 10 millirems per hour.

Low-level waste disposal sites must also meet certain design criteria to minimize the risk of off-site exposure. The criteria include sufficient water table depth to avoid groundwater contamination, lack of seismic activity, physical confinement, and an adequate buffer zone from the population. In addition, operations practices, including groundwater and air monitoring identify high concentrations or releases in order to take appropriate actions to reduce the risk of health effects. **(See also Question H4.)**

Transportation routing, packaging, labeling, training, and documentation requirements are set to minimize the inadvertent release of radioactive or hazardous materials due to an accident. Over the many years of transporting low-level waste, there have been relatively few transportation accidents, and none have resulted in any known health effects. **(See Question F1.)**

J. Opportunities for Public Involvement

1. How can I get involved in decisions about low-level waste management?

There are several opportunities to become involved in decisions regarding low-level waste management. Any major DOE decision regarding management of operations waste will usually involve the preparation of an environmental impact statement. In accordance with the National Environmental Policy Act, the development of an environmental impact statement requires significant public involvement in the beginning or "scoping" part of the process, when major issues to be evaluated are identified, and after the preparation of the draft environmental impact statement. Decisions regarding the management of low-level waste generated from site cleanups will be made under either the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or the Resource Conservation and Recovery Act (RCRA), laws that also require public input on proposed options.

DOE facilities have site-specific advisory boards (SSABs), which include appointed citizen representatives. They generally have monthly public meetings to discuss a variety of waste management and environmental restoration issues. **(See sidebar: *Fernald Citizens Task Force Charts Path for a Quicker Cleanup*.)** Additional public involvement opportunities are available at DOE facilities in conjunction with meetings with state and EPA regulators.

There may be various opportunities for public involvement during state and local decision-making about radioactive waste management. Local or national nongovernmental or advocacy organizations that are active on low-level waste issues also offer opportunities for getting involved.

2. How can I learn more?

- Read the suggested reference materials, in Appendix C
- Visit the Web sites or contact the organizations and agencies listed in Appendix C,
- Contact the public affairs office at any of the DOE facilities that manage radioactive waste,
- Contact tribal, state, or local agencies responsible for radioactive materials or low-level waste disposal, or
- Visit one of the many DOE reading rooms around the country. **(See Appendix C.)**

Also, public libraries are a good source of information, and most libraries offer access to the Internet.

Fernald Citizens Task Force Charts Path for a Quicker Cleanup

The Fernald Feed Materials Production Center, 20 miles north of Cincinnati, Ohio, produced high quality uranium metals for the nuclear weapons complex for nearly 40 years. When it ceased operations in 1989, the site assumed a new mission – cleanup – and a new name – the Fernald Environmental Management Project (FEMP). Fernald's new challenge was to manage more than 2.3 million cubic meters of contaminated soil and debris from uranium production and cleanup operations.

Because of local grassroots activity arising from concern over the extent of the contamination, the Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Ohio Environmental Protection Agency (OEPA) established a site-specific advisory board (SSAB), the Fernald Citizens Task Force, representing citizens, local government, unions, business, and academia. The government agencies asked the task force to make recommendations regarding four questions:

1. What should be the future use of the Fernald site?
2. What residual risk and remediation levels should remain following remediation?
3. Where should waste materials be disposed?
4. What should be the priorities among remedial actions?

Perhaps the most difficult issue that the task force addressed was recommending how to manage waste materials. The task force established primary goals of protecting human health and the Great Miami Aquifer, a drinking water source. The task force felt that Fernald was not an ideal location for the disposal of contaminated materials because of its location above the aquifer and next to agricultural and residential land. However, the task force recognized that it could best achieve its goals by considering both on-site and off-site disposal. They weighed a number of factors:

- Sending all waste off-site would increase health and safety risks from transportation.
- Both Utah and Nevada, likely recipients of Fernald waste shipped off-site, encouraged the site to consider a balanced approach, i.e., managing more waste on-site.
- Getting the most hazardous materials off-site as soon as possible was a priority that could be more readily achieved both politically and financially by managing significant quantities of low-level waste on-site.
- DOE was increasingly encountering funding constraints and competing priorities; off-site disposal would be roughly three times the cost of on-site disposal.
- There would be relatively little risk managing low-level wastes on-site with certain waste acceptance criteria.

The task force recommended that approximately 1.8 million cubic meters be managed on-site in a CERCLA disposal cell. **(See figure 21.)** The task force's deliberations were instrumental in the cleanup decisions made by EPA, OEPA, and DOE. More waste would have been shipped off-site in previously anticipated options. The task force's overall recommendations are expected to achieve protection more quickly and cost less money.

Appendix A
List of Acronyms

AEA	Atomic Energy Act
AEC	Atomic Energy Commission
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DoD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
EIS	Environmental Impact Statement
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
FEMP	Fernald Environmental Management Project
HLW	high-level waste
HMTA	Hazardous Materials Transportation Act
HW	hazardous waste
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
INEEL	Idaho National Engineering and Environmental Laboratory
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
LLW	low-level waste
MLLW	mixed low-level waste
NAS	National Academy of Sciences
NEPA	National Environmental Policy Act
NORM/NARM	naturally occurring and accelerator-produced radioactive materials
NPL	National Priority List for the Superfund program
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Administration
pCi/L	picocuries per liter
PEIS	Programmatic Environmental Impact Statement
rad	radiation absorbed dose
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
RERT	EPA Radiological Emergency Response Team
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SRS	Savannah River Site
TRU	transuranic waste
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
WAC	Waste Acceptance Criteria
WIPP	Waste Isolation Pilot Plant
WM	Waste Management
WMPEIS	Waste Management Programmatic Environmental Impact Statement

Appendix B
Glossary of Radiation Terms

Above ground vault — Disposal method that involves placing contained waste in a reinforced concrete building that provides for isolation of the waste above the surface. The walls are feet thick and have a sloping roof to aid water runoff.

Accelerator/accelerator waste — Device used to increase the energy of particles, which then collide with other particles. Major types are linear accelerators and circular accelerators. The name refers to the path taken by the accelerated particle.

Alpha particle — A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It has low penetrating power and a short range (a few centimeters in air). The most energetic alpha particle will generally fail to penetrate the dead layers of cells covering the skin and can be easily stopped by a sheet of paper. Alpha particles are hazardous when an alpha-emitting isotope is inside the body.

Atom —The smallest particle of an element that cannot be divided or broken up by chemical means. It consists of a central core of protons and neutrons**,** called the nucleus. Electrons revolve in orbits in the region surrounding the nucleus.

Atomic Energy Act (AEA) — This 1954 Act created the Atomic Energy Commission (AEC). The AEC later split into the Nuclear Regulatory Commission (NRC) and the Energy and Research and Development Administration (ERDA). ERDA then became part of the Department of Energy (DOE) in 1977. This act encouraged the development and use of nuclear energy and research for the general welfare and the common defense and security of the United States. It is the basis of authority for NRC, DOE, and Environmental Protection Agency (EPA) in regulating radioactive materials defined in the AEA.

Atomic Energy Commission (AEC) — Federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian applications. Energy Reorganization Act of 1974 abolished the ERDA (now part of DOE) and established the NRC.

Background radiation — Radiation from cosmic sources and terrestrial sources, including radon. It does not include radiation from source or byproduct nuclear materials regulated by the Nuclear Regulatory Commission. The average individual exposure from background radiation is about 300 millirems per year.

Beta particle — A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1,837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Large amounts of beta radiation may cause skin burns, beta emitters are harmful if they enter the body, and beta particles can produce a whole body dose. Beta particles may be stopped by thin sheets of metal, plastic, or glass.

CERCLA (Superfund) — Passed in 1980, the Comprehensive, Emergency Response, and Compensation and Liability Act (also known as Superfund) addresses immediate and long term threats to the public health and the environment from abandoned or active sites contaminated with hazardous or radioactive materials. CERCLA provides for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive

hazardous waste disposal sites. The definition of “hazardous” is much broader under CERCLA than under RCRA and the hazardous substance need not be waste. The Superfund Amendments and Reauthorization Act (SARA) of 1986 reauthorized CERCLA to continue cleanup activities around the country.

Characterization — The determination of waste composition and properties, whether by review or process knowledge, nondestructive examination or assay, or sampling and analysis, generally done for the purpose of determining appropriate storage, treatment, handling, transportation, and disposal requirements.

Compact — A group of two or more states formed to dispose of low-level radioactive waste on a regional basis. Forty-two states have formed nine compacts.

Compaction — Treatment method that involves reducing the volume of noncombustible waste by compressing it into a smaller, denser form.

Composite analysis — An estimate of the potential cumulative impacts to a hypothetical future member of the public from a low-level waste facility and other sources of radioactive materials in the ground that may interact with the low-level waste disposal facility.

Compound — A chemical combination of two or more elements combined in a fixed and definite proportion by weight.

Contaminated environmental media — Naturally occurring materials such as soil, sediment, surface water, groundwater, and other in-place materials (e.g., sludge and rubble/debris that have been disposed of and/or intermixed with soil) that are contaminated at levels requiring further assessment to determine whether an environmental restoration action is warranted.

Contamination — The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or people. It may also be airborne, external, or internal (inside components or people).

Cosmic radiation and Ionizing radiation — both particulate and electromagnetic, originating in outer space.

***de Coulomb* —** the practical meter-kilogram-second unit of electric charge equal to the quantity of electricity transferred by a current of one ampere in one second.

Curie (Ci) — Radioactive atoms are unstable and break down by disintegrating into other atoms. The unit of radioactivity equal to 3.7×10^{10} disintegrations per second or 3.7×10^{10} becquerel (Bq). A common unit used in environmental measurements is the picocurie (pCi) which is equal to $1/10^{-12}$ Ci or 0.037 disintegrations per second or 0.037 Bq.

Decay, radioactive — The decrease in the amount of any radioactive material with the passage of time due to the spontaneous emission of radiation from the atomic nuclei (either alpha or beta particles, often accompanied by gamma radiation).

Decommission — The process of closing down a nuclear facility and reducing radioactivity at the facility to a level safe for unrestricted use.

Decommissioning — The process of removing a facility from operation, followed by decontamination, entombment, dismantlement, or conversion to another use.

Decontamination — The reduction or removal of contaminated radioactive material from a structure, area, object, or person. Decontamination may be accomplished by: (1) treating the surface to remove or decrease the contamination, (2) letting the material stand so that the radioactivity is decreased as a result of natural radioactive decay, or (3) covering the contamination to limit the radiation emitted.

DOE Orders — Written, permanent, and temporary departmental directives affecting more than one Department of Energy (DOE) organization which establish or change policies, organization, methods, standards, or procedures; guide, instruct, and inform employees in their work; require action or impose workload; give information essential to the administration or operation of the department; or transmit other information to employees or contractors of the department when use of DOE publications would not be practicable.

Disposal — Emplacement of waste in a manner that ensures protection of human health and the environment within prescribed limits for the foreseeable future with no intent of retrieval and that requires deliberate action to regain access to the waste.

Disposal facility — A facility or part of a facility where hazardous, radioactive, or solid waste is intentionally placed in or on any land or water, and where waste is intended to permanently remain after closure.

Disposition — Reuse, recycling, sale, transfer, storage, treatment, or disposal.

Dose, absorbed — Represents the amount of energy absorbed from the radiation in a gram of any material. It is expressed numerically in rads.

Dose equivalent, also called biological dose — A measure of the biological damage to living tissue from the radiation exposure. It takes into account the type of radiation and the absorbed dose. For example when considering beta, x-ray, and gamma ray radiation, the equivalent dose (expressed in rems) is equal to the absorbed dose (expressed in rads). For alpha radiation, the equivalent dose is assumed to be twenty times the absorbed dose. It is expressed numerically in rem.

Dose rate — The ionizing radiation dose delivered per unit time. For example, rem per hour.

Dosimeter — A small portable instrument (such as a film badge, thermoluminescent, or pocket dosimeter) for measuring and recording the total accumulated personnel dose of ionizing radiation.

Electromagnetic radiation — Radiation consisting of electric and magnetic waves. A traveling wave motion resulting from changing electric or magnetic fields. It ranges from x-rays (and gamma rays) with short wave length, through the ultraviolet, visible, and infrared regions, to radar and radio waves with relatively long wave length.

Electron — An elementary particle with a negative charge and a mass 1/1,837 that of the proton. Electrons surround the positively charged nucleus and determine the chemical properties of the atom.

Element — One of the 110 known chemical substances that cannot be broken down further without changing its chemical properties. Some examples include hydrogen, nitrogen, gold, lead, and uranium.

Engineered barriers — They are generally used to limit the contact of surface water or groundwater with wastes and migration of contaminants into the surrounding environment. In special cases, they may be used to limit the release of contaminated fluids and gases from leaking waste storage tanks, liquid waste transfer systems, or buried wastes. The most common type of engineered barrier is the surface barrier called a "cap," which is placed over waste deposits.

Environmental Impact Statement (EIS) — A report by federal agencies, prepared in accordance with the National Environmental Policy Act, documents that the information required to evaluate the environmental impact (both positive and negative effects) of a proposed project ("action"). Such a report informs decision-makers and the public of the reasonable alternatives that would avoid or minimize adverse impacts or enhance the quality of the environment. The draft EIS (DEIS) is circulated for public comment before the final EIS (FEIS) is prepared.

Environmental justice — The fair treatment and meaningful involvement of all people – regardless of race, ethnicity, income, or education level – in environmental decisionmaking.

Environmental monitoring — The process of sampling and analyzing environmental media in and around a facility being monitored to (a) confirm compliance with performance objectives and (b) detect any contamination entering the environment early enough to facilitate timely remedial action.

Environmental restoration — Cleanup and restoration of sites, and decontamination and decommissioning of facilities contaminated with radioactive and/or hazardous substances during past production, accidental releases, or disposal activities.

Environmental Restoration Program — A U.S. Department of Energy (DOE) program office concerned with all aspects of assessment and cleanup of both contaminated (radioactive and/or hazardous substances) DOE-owned facilities in use and of DOE sites that are no longer a part of active operations. Remedial actions most often concerned with contaminated soil and groundwater and decontamination and decommissioning are responsibilities of this program.

Fallout, nuclear — The slow decent of minute particles of radioactive debris in the atmosphere following a nuclear explosion.

Federal Facilities Compliance Act (FFCA or FFCAct) — An amendment to RCRA, the FFCA waives immunity for DOE and other federal agencies, allowing states and EPA to impose penalties for non-compliance and requires DOE to develop plans for treating the hazardous components of radioactive wastes subject to RCRA requirements.

Gamma radiation — High-energy, short wave length, electromagnetic radiation emitted from the nucleus. Gamma radiation frequently accompanies alpha and beta emissions. Gamma rays are very penetrating and are best stopped or shielded by dense materials, such as lead. Gamma rays are similar to x-rays.

Geiger-Mueller counter — A radiation detection and measuring instrument. It consists of a gas-filled tube containing electrodes, between which there is an electrical voltage, but no current flowing. When ionizing radiation passes through the tube, a short, intense pulse of current passes from the

negative electrode to the positive electrode and is measured or counted. The number of pulses per second measures the intensity of the radiation field. It is sometimes referred to as simply Geiger counter.

Half-life — The half-life of a radioactive material is the time it takes for half of the material to radiate energetic particles and rays and transform to new materials. For example, the half-life of cesium (Cs-137) is 30 years after which time half of it decays to a non-radioactive stable nuclide, barium (Ba-137). If you start with 100 curies of Cs-137, after 30 years you will have 50 curies of Cs-137 remaining. After 30 more years you will have 25 curies of Cs-137 remaining and so on.

Hazardous waste — A subset of solid wastes that pose substantial or potential threats to public health or the environment and meet any of the following criteria (identified 40 CFR 260 and 261).

- is specifically listed as a hazardous waste by EPA
- exhibits one or more of the characteristics of hazardous waste (ignitability, corrosivity, reactivity, and/or toxicity)
- is generated by the treatment of hazardous waste; or is contained in a hazardous waste

High-level waste (HLW) — High-level waste consists of spent nuclear fuel (primarily from power generation and research), the highly radioactive waste generated during the reprocessing of spent nuclear fuel (primarily from the reprocessing of the used fuel from weapons production reactors in order to obtain material for use in fabricating nuclear weapons.). Reprocessing is the chemical separation of uranium and plutonium from other elements. Because some of its radioactive constituents are very long-lived, high-level waste must be isolated from the environment for tens of thousands of years after disposal.

Incineration — Treatment method that involves the use of an enclosed device using controlled flame combustion to destroy the combustible materials in some low-level waste and mixed low-level waste. The resultant incinerator ash is packaged and disposed of using considerably less space than the original waste volume would have needed.

Institutional controls — Long-term actions or restrictions including monitoring, periodic sampling, access controls, and land use restrictions designed to mitigate any risks posed by contamination following remediation. Institutional controls alone may be sufficient to reduce risks posed by low-levels of contamination.

Ion — (1) An atom that has too many or too few electrons**,** causing it to have an electrical charge, and therefore, be chemically active. (2) An electron that is not associated (in orbit) with a nucleus.

Ionizing radiation — Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. Some examples are alpha, beta, gamma, and x-rays. High doses of ionizing radiation may produce severe skin or tissue damage.

Isotope — One of two or more atoms with the same number of protons, but different numbers of **neutrons** in their nuclei. For example, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon; the number is the sum of the number of neutrons and protons in the nucleus. Isotopes have very nearly the same chemical properties, but often different physical properties (for example, carbon-12 and -13 are stable, carbon-14 is radioactive).

Lead federal agency (LFA) — The federal agency that owns, authorizes, regulates, or is otherwise deemed responsible for ameliorating an emergency and that has the authority to take whatever action is necessary to stabilize the situation.

Local Emergency Planning Committee (LEPC) — A committee appointed by the State Emergency Response Commission (SERC), as required by Title III of Superfund Amendments and Reauthorization Act (SARA), to formulate a comprehensive emergency plan for its district.

Macroencapsulation — An approved immobilization technology used to treat radioactively contaminated lead solids, mixed waste debris, wastewater treatment residues, fly ash, and sludge to solidify and stabilize the waste. Solidifying and stabilizing the waste renders it immobile so that its hazardous constituents will not leach into the surrounding environment.

Maximally (or Most) Exposed Individual — The person with the highest exposure in a given population.

Millirem — Thousandths of a rem.

Mill tailings — Naturally radioactive residue from the processing of uranium ore. Although the milling process recovers about 93 percent of the uranium, the residues, or tailings, contain several naturally occurring radioactive elements, including uranium, thorium, radium, polonium, and radon.

Minimum treatment — (for low-level waste) The least amount of treatment required to allow on-site disposal or transportation to another site for disposal.

Mixed waste — Contains both hazardous waste (as defined by RCRA and its amendments) and radioactive waste (as defined by AEA and its amendments). It is jointly regulated by NRC or NRC's Agreement States and EPA or EPA's RCRA Authorized States. The fundamental and most comprehensive statutory definition is found in the Federal Facilities Compliance Act (FFCA) where Section 1004(41) was added to RCRA: "The term 'mixed waste' means waste that contains both hazardous waste and source, special nuclear, or byproduct material subject to the Atomic Energy Act of 1954."

Molecule — A group of atoms held together by chemical forces. A molecule is the smallest unit of a compound that can exist by itself and retain all of its chemical properties.

Neutron — An uncharged elementary particle with a mass slightly greater than that of the proton, and found in the nucleus of every atom heavier than hydrogen.

Non-ionizing radiation — Radiation that has lower energy levels and longer wave lengths. It is not strong enough to affect the structure of atoms it contacts, but can heat tissue and can cause harmful biological effects. Examples include radio waves, microwaves, visible light, and infrared.

Naturally Occurring or Accelerator Produced Radioactive Materials (NARM) — Radioactive materials not covered under the AEA that are naturally occurring or produced by an accelerator. Accelerators are used in sub-atomic particle physics research. These materials have been traditionally regulated by states.

Naturally Occurring Radioactive Materials (NORM) — NORM is a subset of NARM and refers to materials not covered under the AEA whose radioactivity has been enhanced (radionuclide concentrations are either increased or redistributed where they are more likely to cause exposure to man) usually by mineral extraction or processing activities. Examples are exploration and production

wastes from the oil and natural gas industry and phosphate slag piles from the phosphate mining industry. This term is not used to describe or discuss the natural radioactivity of rocks and soils, or background radiation, but instead refers to materials whose radioactivity is technologically enhanced by controllable practices. Sometimes, it is referred to as TENORM.

Nuclear energy — The heat energy produced by the process of nuclear reaction (fission or fusion) within a nuclear reactor or by radioactive decay.

Nuclear power plant — An electrical generating facility using a nuclear reactor as its power (heat) source. The coolant that removes heat from the reactor core is normally used to boil water. The steam produced by the boiling water drives turbines that rotate electrical generators.

Nucleus — The small, central, positively charged region of an atom that carries the atom's nuclei. All atomic nuclei contain both protons and neutrons (except for ordinary hydrogen, which has a single proton). The number of protons determines the total positive charge, or atomic number.

Performance Assessment (radiological performance assessment) **—** An analysis of a low-level waste disposal facility's ability to contain the waste in order to determine reasonable expectations for performance of the facility over time.

Placard — A warning sign made of a durable material and placed on the exterior sides of a transport vehicle. Represents the hazard class(es) of the material(s) contained within the freight container, motor vehicle, or rail car.

Photon — A quantum (or packet) of energy emitted in the form of electromagnetic radiation. Gamma rays and x-rays are examples of photons.

Picocurie — One trillionth (10^{-12}) of a curie.

Programmatic Environmental Impact Statement (PEIS) — A broad-scope Environmental Impact Statement that identifies and assesses the environmental impacts of a federal program.

Proton — An elementary nuclear particle with a positive electric charge located in the nucleus of an atom.

Rad (radiation absorbed dose) — A rad is a measure of the amount of energy actually absorbed by a material, such as human tissue.

Radiation — All matter is composed of elements, and each element can take many different forms, called isotopes. The difference between isotopes of the same element is in their number of neutrons. Some isotopes are unstable and emit radiation, which is energy given off by atoms when they move or change state. These unstable isotopes are known as radionuclides. Stable isotopes do not emit radiation.

Radiation — Ionizing radiation is comprised of highly energetic and penetrating x-rays and gamma rays and lesser penetrating particles. Beta particles are simply energetic electrons**,** and alpha particles are helium nuclei both arising from the nucleus of a decaying atom. The alpha particle is the easiest of these to stop and the gamma rays are the most difficult to shield against. A piece of paper can stop an alpha particle, but it may take as much as many inches of lead shielding to stop most of the x-rays or gamma rays in a beam. Depending on the dose, kind of radiation, and ob-

served endpoint, the biological effects of radiation can differ widely. Ionizing radiation has been proven to cause cancer at high doses and is assumed to cause cancer and other deleterious health effects at low doses.

Radiation standards — Exposure limits, permissible concentrations, rules for safe handling, regulations for transportation, and regulations controlling the use of radiation and radioactive material.

Radiation warning symbol — An officially prescribed symbol (a magenta or black trefoil) on a yellow background that must be displayed where certain quantities of radioactive materials are present or where certain doses of radiation could be received.

Radioactive contamination — Deposition of radioactive material in any place where it may harm persons, equipment, or the environment.

Radioactive waste — Solid, liquid, or gaseous material that contains radionuclides regulated under the Atomic Energy Act of 1954, as amended, and of negligible economic value considering costs of recovery.

Radioactive waste disposal — The isolation of radioactive wastes from the accessible environment and emplacement in a repository with no foreseeable intent of recovery, whether or not such emplacement permits the recovery of such waste.

Radioactivity — The emission of radiation, generally alpha or beta particles, often accompanied by gamma rays, from the nucleus of an unstable isotope. Also, the rate at which radioactive material emits radiation.

Radioisotope — An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation.

Radionuclide — Unstable atom. Approximately 5,000 radionuclides have been identified.

Radon (Rn) — A radioactive element that is one of the heaviest gases known. Its atomic number is 86. It is found naturally in soil and rocks and is formed by the radioactive decay of radium.

Reactor, nuclear — A device in which nuclear fission may be sustained and controlled in a self-supporting nuclear reaction. There are many varieties.

Record of Decision (ROD) — A public document that records the final decision(s) on a proposed action. The Record of Decision is based in whole or in part on information and the technical analysis generated either during the Comprehensive Environmental Response, Compensation, and Liability Act process or the National Environmental Policy Act process, both of which take into consideration public comments and community concerns.

Rem (roentgen equivalent man) — The rem is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Equivalent dose is often expressed in terms of thousandths of a rem, or mrem.

Resource, Conservation, and Recovery Act (RCRA) — RCRA gave EPA authority to control hazardous waste from “cradle-to-grave.” This includes the minimization, generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the

management of non-hazardous solid wastes. RCRA focuses only on active and future facilities and does not address abandoned or historical sites (see CERCLA).

Roentgen (R) — A unit of exposure to gamma rays or x-rays. It is the amount of gamma or x-rays required to produce ions resulting in a charge of 0.000258 coulombs/kilogram of air in cubic meter or air under standard conditions.

Shallow land burial ground — Disposal method that involves placing packaged waste in a shallow trench or pit. A closure cap made of clay or some other low-permeability cover, gravel drainage layers, and a topsoil layer, are then placed on top of the contained waste. The layers are contoured and replanted with vegetation for drainage and erosion control.

Shipper — The person (or his or her agent) who tenders a shipment for transportation. The term includes persons who prepare packages for shipment, and offer packages to a carrier for transportation by signature on the shipping paper. (DOE Order 1540.1A)

Sorbent — A substance that takes up and holds by adsorption (adhesion to the surface of a solid or liquid) or absorption (take up as part of the existent whole).

Spent (depleted) fuel — Nuclear reactor fuel that has been used to the extent that it can no longer effectively sustain a chain reaction.

State Emergency Response Commission (SERC) — Commission appointed by each state governor according to the requirements of Title III of Superfund Amendments and Reauthorization Act (SARA); duties of the commission include designating emergency planning districts, appointing Local Emergency Planning Committees (LEPCs), supervising and coordinating the activities of planning committees, reviewing emergency plans, receiving chemical release notifications, and establishing procedures for receiving and processing requests from the public for information.

Storage — The collection and containment of waste for the purposes of awaiting treatment or disposal capacity (i.e., not short-term accumulation).

Storage, Long-Term — The containment of waste (usually after undergoing treatment) for a period of years, possibly decades, until ultimate permanent disposal.

Transport Index — The dimensionless number (rounded up to the next tenth) placed on the label of a package, to designate the degree of control to be exercised by the carrier during transportation. It is equal the maximum radiation level in millirem per hour at one meter (3.3 ft) (for non-fissile materials packages.)

Terrestrial radiation — Radiation that is emitted by naturally occurring radioactive materials, such as uranium, thorium, and radon in the earth.

Treatment — Any method, technique, or process designed to change the physical or chemical character of the waste to render it less hazardous; safer to transport, store, or dispose of; or reduced in volume.

Unstable isotope — A radioactive isotope.

Volume reduction — A variety of techniques that reduce the overall disposal volume of low-level waste. Volume reduction uses technologies, including incineration, compaction/supercompaction,

size reduction, and evaporation/concentration.

Waste Acceptance Criteria (WAC) — The requirements specifying the characteristics of waste and waste packaging acceptable to a waste receiving facility and the documents and processes the generator needs to certify that waste meets applicable requirements.

Waste management — the planning, coordination, and direction of those functions related to generation, handling, treatment, storage, transportation, and disposal of waste, as well as associated pollution prevention, surveillance, and maintenance activities.

Waste Management Program — A U.S. Department of Energy (DOE) program office concerned with all aspects of waste management associated with radioactive and/or hazardous substances generated by DOE owned facilities.

Waste minimization — An action that economically avoids or reduces the generation of waste by source reduction, by reducing the toxicity of hazardous waste, by improving energy usage, or by recycling. These actions will be consistent with the general goal of minimizing present and future threats to humans and other environment.

Waste, radioactive — Solid, liquid, and gaseous materials from nuclear operations that are radioactive or become radioactive and for which there is no further use.

Whole Body Exposure — An exposure of the body to radiation, in which the entire body, rather than an isolated part, is irradiated.

X-rays — One type of electromagnetic radiation which arises as electrons are deflected from their original paths or inner orbital electrons change their orbital levels around the atomic nucleus. Like gamma rays, x-rays require more shielding to reduce their intensity than do beta or alpha particles.

Sources:

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DOE Glossary of Transportation/Packaging Terms, DOE National Transportation Program; http://www.ntp.doe.gov/trpgglos.html.

Health Physics Society Fact Sheets; http://www.hps.org/publicinformation/radfactsheets

DOE - Lawrence Berkeley Laboratory, Glossary; http://ie.lbl.gov/education/glossary/glossary.htm

PBS Glossary of Nuclear Terms; http://www.pbs.org/wgbh/pages/frontline/shows/reaction/etc/terms.html

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Appendix C
Resources

Federal Agencies

U.S. Department of Energy

- Environmental Management
  Forrestal Building
  1000 Independence Avenue, SW
  Washington, DC 20585
  Phone: 202-586-5000
  http://www.em.doe.gov

- Fernald Environmental Management Project
  http://www.fernald.gov

- National Transportation Program
  http://www.ntp.doe.gov/

- Nevada Operations
  http://www.nv.doe.gov

The U.S. Department of Energy is the federal agency responsible for developing and managing the country's nuclear weapons, environmental cleanup of the nuclear weapons complex, nonproliferation and stewardship of the nuclear stockpile, energy efficiency and conservation, technology transfer, and basic science research. In addition, DOE has more than 30,000 scientists and engineers conducting research.

U.S. Environmental Protection Agency

- Radiation Protection Programs
  Ariel Rios Building
  1200 Pennsylvania Avenue, NW
  Washington, DC 20460
  Phone: 202-564-9290
  http://www.epa.gov/radiation

The U.S. Environmental Protection Agency (EPA) is an independent federal agency that works to protect human health and to safeguard the natural environment – air, water, and land.

- Headquarters Information Resources Center
  401 M Street, SW
  Mailcode 3404
  Washington, DC 20460
  Phone: 202-260-5922
  Fax: 202-260-5153
  library-hq@epamail.epa.gov

The EPA Headquarters Information Resources Center (IRC) provides access to EPA information.

U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852-2738
Phone: 301-415-7000
http://www.nrc.gov

The U.S. Nuclear Regulatory Commission (NRC) is an independent federal agency responsible for overseeing the use of nuclear materials in the United States. NRC's scope of responsibility includes regulation of commercial nuclear power reactors; medical, academic, and industrial uses of nuclear materials; and the transport, storage, and disposal of nuclear materials and waste.

U.S. Department of Transportation
Federal Motor Carrier Safety Administration
400 Seventh Street, SW
Washington, DC 20590
Phone: 202-366-0456
Fax: 202-366-7298
http://www.fmcsa.dot.gov

The Federal Motor Carrier Safety Administration's primary mission is to prevent commercial motor vehicle-related fatalities and injuries. Administration activities contribute to ensuring safety in motor carrier operations through strong enforcement of safety regulations, targeting high-risk carriers and commercial motor vehicle drivers; and improving safety information systems and commercial motor vehicle technologies.

Non-Profit Organizations

Alliance for Nuclear Accountability
Seattle Office:
1914 N. 34th St, Suite 407
Seattle, WA 98103
Phone: 206-547-3175
Fax: 206-547-7158
DC Office:
1801 18th St., NW, Suite 9-2
Washington, DC 20009
Phone: 202-833-4668
Fax: 202-234-9536
ananuclear@earthlink.net
http://www.ananuclear.org/

The Alliance for Nuclear Accountability (ANA) is a network of more than 30 local, regional and national peace and environmental groups representing the concerns of communities near U.S. nuclear weapons sites and radioactive waste dumps.

American Nuclear Society
555 North Kensington Avenue
La Grange Park, Illinois 60526
Phone: 708-352-6611
Fax: 708-352-0499
nucleus@ans.org
http://www.ans.org

The American Nuclear Society is a not-for-profit, international, scientific and educational organization. Its membership includes approximately 13,000 individuals representing more than 1,600 corporations, educational institutions, and government agencies.

Concerned Citizens for Nuclear Safety
107 Cienega
Santa Fe, NM 87501
Phone: 505-982-5611
Fax: 505-986-0997
ccns@nets.com
http://www.nuclearactive.org/

Concerned Citizens for Nuclear Safety is a nonprofit, nonpartisan organization that works to increase public awareness about radioactivity and the nuclear industry. It particularly focuses on Los Alamos National Laboratory (LANL) and the Waste Isolation Pilot Plant (WIPP).

Conference of Radiation Control Program Directors, Inc.
205 Capital Avenue
Frankfort, KY 40601
Phone: 502-227-4543
Fax: 502-227-7862
http://www.crcpd.org/

The Conference of Radiation Control Program Directors, Inc. (CRCPD) is a nonprofit professional organization whose primary membership is made up of individuals in state and local government who regulate the use of radiation sources, and others interested in radiation protection.

Health Physics Society
1313 Dolley Madison Boulevard Suite 402
McLean, Virginia 22101
Phone: 703-790-1745
Fax: 703-790-2672
hps@BurkInc.com
http://www.hps.org

The Health Physics Society is an international professional scientific organization that is active in all aspects of radiation protection including information dissemination, standards development, education, preparation of position papers, and promotion of scientific conferences and committees.

Institute for Energy and Environmental Research
6935 Laurel Avenue
Takoma Park, MD 20912
Phone: 301-270-5500
Fax: 301-270-3029
ieer@ieer.org
http://www.ieer.org

The Institute for Energy and Environmental Research is a nonprofit organization funded primarily through private foundation grants. It provides activists, policymakers, journalists, and the public with understandable scientific and technical information on energy and environmental issues, particularly nuclear materials and technologies.

League of Women Voters
1730 M Street NW, Suite 1000
Washington, DC 20036-4508
Phone: 202-429-1965
Fax: 202-429-0854
http://www.lwv.org

The League of Women Voters, a nonpartisan political organization, encourages the informed and active participation of citizens in government, works to increase understanding of major public policy issues, and influences public policy through education and advocacy.

National Association of Attorneys General
750 First Street, NE, Suite 1100
Washington, DC 20002
Phone: 202-326-6000
Fax: 202-408-7014
http://www.naag.org/index2.html

NAAG handles dozens of federal-state working groups, sponsors more than 30 seminars, conferences, summits, emerging issue forums, and special events yearly for state Attorneys General and their staffs. They publish written reports, monographs, and more than a dozen newsletters on a wide range of substantive topics.

National Conference of State Legislatures
444 North Capitol Street, NW, Suite 515
Washington, DC 20001
Phone: 202-624-5400
Fax: 202-737-1069
http://www.ncsl.org/

The National Conference of State Legislatures is a bipartisan organization dedicated to serving the lawmakers and staffs of the nation's 50 states, its commonwealths and territories. The Conference is a source for research, publications, consulting services, meetings, seminars and information exchange.

National Council on Radiation Protection and Measurements
7910 Woodmont Avenue, Suite 800
Bethesda, MD 20814-3095
Phone: 301-657-2652
Fax: 301-907-8768
ncrp@ncrp.com
http://www.ncrp.com

The National Council on Radiation Protection and Measurements (NCRP) seeks to formulate and disseminate information, guidance, and recommendations on radiation protection and measurements, which represent the consensus of leading scientific thinking.

National Governors' Association
Hall of States
444 North Capitol Street
Washington, DC 20001-1512
Phone: 202-624-
http://www.nga.org
webmaster@nga.org

The National Governors' Association is the bipartisan national organization of, by, and for the nations' governors. Its members are the governors of the fifty states, the commonwealths of the Northern Mariana Islands and Puerto Rico, and the territories of American Samoa, Guam, and the Virgin Islands.

National Safety Council
Environmental Health Center
1025 Connecticut Avenue, NW, Suite 1200
Washington, DC 20036
Phone: 202-293-2270
Fax: 202-293-0032
ehc@nsc.org
http://www.nsc.org/ehc.htm

The Environmental Health Center is a division of the National Safety Council, a non-governmental, nonprofit public service organization. EHC provides information and resources on a range of environmental issues.

Natural Resources Defense Council
40 West 20th Street
New York, NY 10011
Phone: 212-727-2700
Fax: 212-727-1773
http://www.nrdc.org
nrdcinfo@nrdc.org

NRDC uses law, science, and the support of more than 400,000 members nationwide to protect the planet's wildlife and wild places and to ensure a safe and healthy environment for all living things.

Nuclear Energy Institute
176 I Street, NW, Suite 400
Washington, DC 20006
Phone: 202-739-8009
Fax: 573-445-2135
swp@nei.org
http://www.nei.org

The Nuclear Energy Institute represents the commercial nuclear energy industry. It advocates policies that ensure the beneficial uses of nuclear energy and related technologies.

Nuclear Information and Resources Service
1424 16th Street, NW, Suite 404
Washington, DC 20036
Phone: 202-328-0002
Fax: 202-462-2183
nirsnet@nirs.org
http://www.nirs.org

The Nuclear Information and Resources Service is an information and networking center for citizens and environmental organizations concerned about nuclear power, radioactive waste, radiation, and sustainable energy issues.

Physicians for Social Responsibility
1101 14th Street Northwest, Suite 700
Washington, DC 20005
Phone: 202-898-0150
Fax: 202-898-0172
psrnatl@psr.org
http://www.psr.org/

Physicians for Social Responsibility works towards elimination of nuclear weapons and addresses environmental threats, such as global warming, ozone depletion, toxic chemicals, and the world population explosion.

Southern States Energy Board
6325 Amherst Court
Norcross, GA 30092
Phone: 770-242-7712
Fax: 770-242-0421
http://www.sseb.org

The Southern States Energy Board (SSEB) is a nonprofit interstate compact organization of 16 southern states and two territories. SSEB develops, promotes, and recommends policies and programs which protect and enhance the environment without compromising the needs of future generations. It has a Radioactive Materials Transportation Committee, which participates in the policymaking process concerning Department of Energy's radioactive materials transportation programs.

Union of Concerned Scientists
2 Brattle Square,
Cambridge, MA 02238-9105
Phone: 617-547-5552
ucs@ucsusa.org
http://www.ucsusa.org

The Union of Concerned Scientists is an independent nonprofit organization representing scientists and other citizens around the country. It does research, public education, and citizen advocacy particularly on environmental and related issues.

Western Governors' Association
600 17th Street
Denver, CO 80202-5452
Phone: 303-623-9378
wga@csn.gov
http://www.westgov.org

The Western Governors' Association is an independent, non-partisan organization of governors from 18 western states, two Pacific-flag territories and one commonwealth. The Association addresses key policy and governance issues in natural resources, the environment, human services, economic development, international relations, and public management.

International Organizations

International Atomic Energy Agency
P.O. Box 100, Wagramer Strasse 5
A-1400 Vienna, Austria
Phone: +43-1-2600-0
Fax: +43-1-2600-7
Official.Mail@iaea.org
http://www.iaea.org

The International Atomic Energy Agency serves as the world's central intergovernmental forum for scientific and technical cooperation in the nuclear field and as the international inspector of nuclear safeguards and verification measures in civilian nuclear programs.

International Commission on Radiological Protection
S-171 16 Stockholm, Sweden
Phone: +46-8-7297275
Fax: +46-8-7297298
jack.valentin@ssi.se
http://www.icrp.org

The Commission works to advance the science of radiological protection for the public benefit, in particular by providing recommendations on all aspects of radiation protection.

Publications

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Web Sites

Low-Level Waste Forum, http://www.afton.com/llwforum

The Radiation Information Network, http://www.physics.isu.edu/radinf/index.html

Transportation Resource Exchange Center, http://trex-center.org

DOE Reading Rooms and Libraries

U.S. DOE Headquarters
1000 Independence Avenue, SW
Washington, DC 20585
Phone: 202-586-5955

Albuquerque Operations
Office of External Affairs
Wyoming Blvd. P.O. Box 5400
Albuquerque, NM 87185-5406
Phone: 505-845-4370

- Grand Junction Project Office
  Technical Resource Center
  2597 B 3/4 Road
  Grand Junction, CO 81501
  970-248-7634 (Janie Gueretta)

- Mid-Continent Public Library
  The Blue Ridge Library
  9253 Blue Ridge Boulevard
  Kansas City, MO 64138
  816-761-3382 (Jean Heandershot)

- Communtity Relations Office
  Sharon Rivera
  1619 Central Avenue
  Los Alamos, NM 87545

- Pantex Plant
  Carson County Library
  P.O. Box 339
  Panhandle, TX 79068
  806-537-3742

- Pinellas Plant
  Florida Pinellas Park Library
  7770 52nd Street
  Pinellas Park, FL 33781

- Sandia National Laboratory CA
  SNL/CA Public Reading Room
  7011 East. Avenue, Building 901
  Livermore, CA 94550

- Public Document Collection
  University of NM Gov. Infer. Dept.
  Zimmerman Library
  Albuquerque, NM 87131
  505-277-0582 (Teresa Marquez)
  505-277-7180 (Dan Barkley)

- Amarillo College
  Amarillo Learning Center
  Lynn Library
  Amarillo, TX 79178
  806-371-5400 (Karen McIntosh)

- Carlsbad Public Library
  101 South Halagueno
  Carlsbad, NM 88220
  505-885-6776 (Lori Mitched)

Chicago Operations
9800 S. Cass Avenue
Argonne, IL 60439
Phone: 630-252-2013

- Ames Laboratory Iowa
  Ames Public Library
  Reference Section
  515 Douglas Avenue
  Ames, IA 50010
  515-239-5645

- Argonne National Laboratory
  Lemont Public Library
  50 Wend Street
  Lemont, IL 60439

630-257-6541

¨ Argonne National Laboratory
Indian Prairie Public Library
Reference Station
401 Plainfield Road
Darien, IL 60561
630-887-8760

¨ Brookhaven National Laboratory
Public Information Office
3233 Route 112
Medford, NY 11763
516-451-6260

¨ Brookhaven National Laboratory
Research Library
Building 477 A
Upton, NY 11973
516-399-1511

Idaho Operations
U.S. DOE
785 DOE Place
Idaho Falls, ID 83401
Phone: 208-526-0111

¨ INEEL Technical Library
DOE Public Reading Room
1776 Science Center Drive
Idaho Falls, ID 83415

¨ Albertson Library
Boise State University
1910 University Drive
Boise, ID 83725

¨ University of Idaho
University of Idaho Campus
432 2nd Street
Moscow, ID 83843

Nevada Operations
U.S. DOE
2332 Energy Way
Las Vegas, NV 89193-8518
Phone: 800-405-1140

Oak Ridge Operations
U.S. Doe
P.O. Box 2001
Oak Ridge, TN 37831
Phone: 423-576-1216

¨ K-25 Site, Oak Ridge Reservation TN
DOE Environmental Information
Resource
105 Broadway
Oak Ridge, TN 37830
423-481-0695

¨ Middlesex Sampling Plant NJ
Maywood DOE Public Information Center
43 West Pleasant Avenue
Maywood, NJ 07607
201-843-7466

¨ Public Reading Room
230 Warehouse Road
Building 1916-T2, Suite 300
Oakridge, TN 37830
423-241-4582

¨ Oak Ridge Information Resource Center
150 Broadway
Oak Ridge, TN 37830
423-241-4582

¨ Portsmouth Site Office
P.O. Box 693
Piketon, OH 45661
740-289-3317

Oakland Operations
U.S. DOE
Energy Information Center
1307 Clay Street
180 N
Oakland, CA 9412
Phone: 510-637-1762

Ohio Operations
U.S. DOE
Fernald Operations Office
P.O. Box 398705
Cincinnati, OH 45239-8705
Phone: 513-648-7480 (Diana Rayer)

¨ Fernald Environmental Management Project
Public Environmental Information Center
Jamtek Building
10845 Hamilton Cleves Highway
Harrison, OH 45030

¨ Mound Plant Ohio
Miamisburg Senior Adult Center
Public Reading Room
305 Central Avenue
Miamisburg, OH 45342

Princeton Plasma Physics Laboratory
Middlesex County Library
Plainsboro Branch
641 Plainsboro Road
Plainsboro, NJ 08536
Phone: 609-275-2897

Richland Operations Office
U.S. DOE Reading Room
2770 University Drive
CIC, Rm. 101L
P.O. Box 999, MS H2-53
Richland, WA 99352
Phone: 509-372-7443 (Terry Trauh)

¨ Westinghouse Hanford Company
Environmental Data Management Center
2420 Stevens Ctr Place, Room I 101
Richland, WA 99352
509-376-1418

Rocky Flats Operations
U.S. DOE
Environmental Restoration Division
10808 Highway 93, Unit A
P.O. Box 928
Golden, CO 80403-8200
Phone: 303-966-6312

¨ Rocky Flats Environmental Tech. Site
Reading Room
Front Range Community College Library
3645 West I 2nd Avenue
Westminister, CO 80030
303-469-4453

¨ Front Range Community College
3705 W. 112th Avenue
Westminister, CO 80030
303-469-4435

¨ Rocky Flats Citizen Advisory Board
9035 N. Wadsworth Parkway
Suite 2250
Westminister, CO 80021
303-420-7855

¨ Colorado Dept. of Public Health and Environment
Information Center
4300 Cherry Creek Drive South, Bldg. A
Denver, CO 80222-1530
303-692-3312

¨ U.S. EPA
Region VIII Superfund Records Center
999 18th Street, Suite 500
Denver, CO 80202-2466
303-312-6437

¨ Standley Lake Public Library
8485 Kipling Street
Arvada, CO 80005
303-456-0806

Savannah River Operations
U.S. DOE
P.O. Box A
Aiken, SC 29802
Phone: 803-725-2467

¨ Savannah River Site
Gregg- Graniteville Library
University of South Carolina-Aiken
Aiken, SC 29801

Appendix D
Chronology of Radiation and Radioactive Waste in the United States

1895 Roentgen discovers x-rays.
1896 First diagnostic x-ray in United States.
1898 Marie and Pierre Curie coin word “radioactivity.”
1903 Marie and Pierre Curie awarded the Nobel Prize for Physics.
1910 Curie unit defined as activity of 1 gram of radium.
1928 U.S. Advisory Committee on X-ray and Radium Protection established (predecessor of NCRP)
1939 Enrico Fermi patents first reactor (conceptual plans).
1946 Atomic Energy Act is passed; establishes Atomic Energy Commission.
1946 U.S. Advisory Committee renamed National Committee on Radiation Protection.
1951 First electricity is generated from atomic power at INEEL.
1954 Atomic Energy Act of 1954 passed.
1957 UN establishes the International Atomic Energy Agency (IAEA)
1962 The first commercial low-level waste disposal site was established in Beatty, Nevada.
1970 National Environmental Policy Act of 1969 requires the federal government to review the environmental impact of any action that might significantly affect the environment.
1974 Nuclear Regulatory Commission established.
1976 Resource Conservation and Recovery Act (RCRA) is passed to protect human health and the environment from the potential hazards of waste disposal.
1979 Three Mile Island (Middletown, PA) nuclear reactor suffers hydrogen explosions and meltdown completely destroying its core.
1980 Low-Level Radioactive Waste Policy Act is passed, making states responsible for the disposal of their own commercial low-level nuclear waste.
1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund) is passed. Under Superfund, EPA identifies hazardous sites, takes appropriate action, and sees that the responsible party pays for the cleanup.
1989 Cold War ends. DOE changes its focus from nuclear materials production to environmental cleanup and forms the Office of Environmental Restoration and Waste Management.
1989 Defense Nuclear Facilities Safety Board (DNFSB) established to oversee safety at defense nuclear facilities.
1992 The Federal Facilities Compliance Act made federal facilities subject to the provisions of the RCRA as of 1995.
1994 Defense Nuclear Facilities Safety Board calls for (recommendation 94-2) a complex-wide review of low-level waste management environment, safety, and health vulnerabilities.
1997 DOE published its Final Waste Management Programmatic Environmental Impact Statement (WMPEIS) which evaluated the environmental effects of alternatives for managing DOE’s wastes, including low-level waste and mixed low-level waste.

1998 In a unique arrangement, the State of Nevada and DOE agreed to amend to their existing agreement, laying out the responsibilities of the Nevada Division of Environmental Protection and the DOE Nevada Operations Office.

1999 All corrective actions called for in the "Complex-Wide Review" were completed.

2000 DOE announced its new policy for treating and disposing of low-level waste. The decision was put forth in the form of a Record of Decision (ROD).

Sources:

- *A Brief Chronology of Radiation and Protection*, by J. Ellsworth Weaver III 1994,1995, http://www.sph.umich.edu/eih/UMSCHPS/chrono.htm#top
- *The Nuclear Waste Primer*, League of Women Voters, 1993

Appendix E
Commercial Low-Level Waste

Commercial low-level waste is generated as a result of activities conducted for civilian or commercial purposes. It can also include some government-generated waste, but it does not include any waste managed by the Department of Energy. The regulatory and institutional systems for managing DOE low-level waste and commercial low-level waste differ in a number of ways. The differences are important to keep in mind when considering the overall issue of low-level waste in the United States.

Sources of Commercial Low-Level Waste

Commercial low-level waste is generated in all 50 states by approximately 21,700 facilities licensed to use radioactive materials, including nuclear power plants, industry and research activities, medical facilities, and government facilities.

- **Nuclear Power Plants** — Low-level waste from commercial nuclear power plants can include various items that have been contaminated with radioactive material, such as pipes, pumps, valves, and filters; tools and equipment; and protective clothing used by workers. When a reactor is decommissioned, it produces additional low-level waste.

- **Industry and Research** — Commercial facilities and academic institutions use radiation for a variety of activities, such as measuring the thickness of materials or cold-sterilizing plastics, pharmaceuticals, cosmetics, and other heat-sensitive products. These activities result in radioactively contaminated equipment. In addition, products such as some smoke detectors, exit signs, and some gauges contain radioactive materials.

- **Medical Facilities** — Radioactive materials are used in a wide variety of medical diagnostic procedures such as x-rays and treatment procedures such as radiation therapy for cancer, and to sterilize medical equipment.

- **Non-DOE Government Sources —** Various U.S. government agencies, such as the Department of Defense, the Veteran's Administration, and the Department of Agriculture, generate low-level radioactive waste similar to that generated by hospitals and universities.

Types of Commercial Low-Level Waste

The Nuclear Regulatory Commission (NRC) separates commercial low-level waste into classes depending on the hazard it presents: Classes A (the lowest hazard), B, C, and Greater than Class C (the highest hazard). The classification of the waste depends on the concentration of radioactivity, its half-life, and the types of radionuclides it contains.

States are responsible for disposal of A, B, and C wastes. The Department of Energy is responsible for disposal of Greater than Class C waste, which has the highest concentration of radioactivity. These wastes must be disposed of in an NRC licensed facility and are generally not acceptable for near-surface disposal. Additionally, these wastes are not currently authorized for disposal in a geologic repository under the Nuclear Waste Policy Act, but must be isolated from human exposure for periods in excess of hundreds or thousands of years.

About 95 percent (by volume) of all low-level waste is categorized as Class A.

Storage of Commercial Low-Level Waste

Commercial low-level radioactive waste must be stored in a manner that maintains radiation doses to workers and members of the public below levels specified by NRC. Requirements vary depending on the level of hazard. Some low-level radioactive wastes require shielding with lead, concrete, or other materials to protect workers and members of the public.

Low-level radioactive waste is stored primarily in special containers, rooms, or buildings at the site of generation such as hospitals, research facilities, clinics, and nuclear power plants. Some waste is stored on site until it decays to a safe level and can be disposed of with non-radioactive waste. Other waste is stored temporarily until it can be transported to a permanent disposal facility.

Disposal of Commercial Low-Level Waste

The Low-Level Radioactive Waste Policy Act of 1980, as amended, makes each state responsible for assuring adequate disposal capacity for low-level waste and mixed low-level waste generated within the state, except for waste generated by defense-related activities. The law also encourages states to establish interstate agreements to work together in groups of states, known as compacts, to establish disposal facilities. **(See figure 23.)**

NRC and EPA have developed regulations stipulating minimum site suitability criteria for commercial

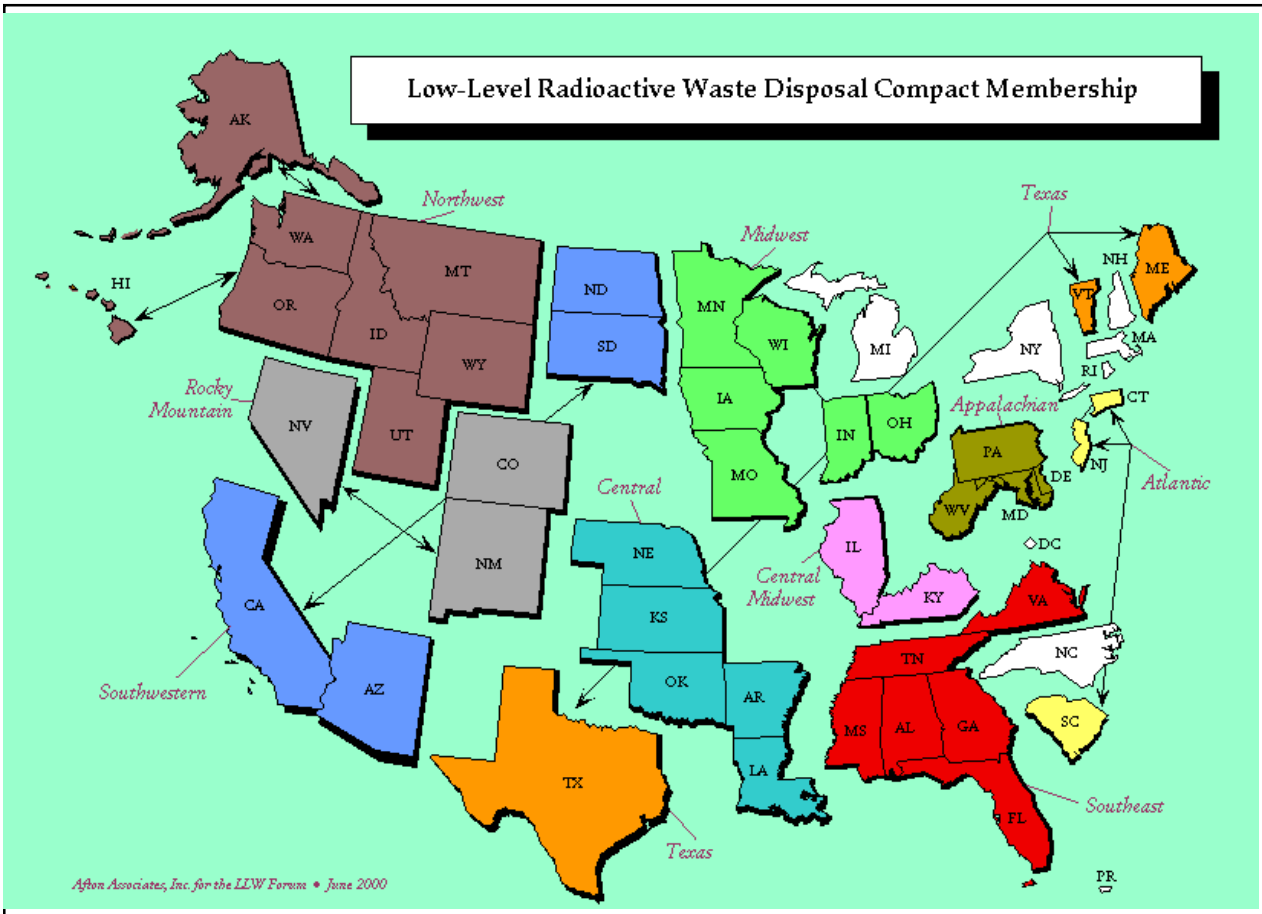

Figure 23. Low-Level Radioactive Waste Disposal Compact Membership (Source: Afton Associates, Inc. for the LLW Forum)

low-level radioactive waste land disposal facilities and minimum location standards for hazardous waste treatment, storage, and disposal facilities. The standards include requirements relating to population density, surface and groundwater conditions, soil types, and climate.

Some commercial facilities are now closed, including Beatty, Nevada, and Maxey Flats, Kentucky, which experienced operating difficulties. Damaged and leaking containers were being delivered to Beatty, and some radioactive materials migrated from Maxey Flats, a Superfund site. As of fall 2000, commercial low-level radioactive waste was being disposed of at three commercial facilities — Barnwell Waste Management, near DOE's Savannah River Site in South Carolina; US Ecology, which leases space at DOE's Hanford Site in Richland, Washington; and Envirocare of Utah, Inc. in Clive, Utah. At the same time 43 states were organized into 10 state compacts, but none of the compacts or states acting alone had successfully opened a new disposal facility.

The general public may review and comment on the license application, initial license, and subsequent amendments for the development of new commercial low-level waste disposal facilities. More information about commercial low-level waste management is available from The Low-Level Radioactive Waste Forum at http://www.afton.com/llwforum/.

Appendix F
Transportation External Coordination Working Group Membership

TEC/WG members are representatives from national, regional, tribal, state, and local governmental and industry/professional groups. In an effort to minimize the potential for "capture" by parochial interests and to maximize the opportunity for broad-based decision making, no single state, local, or tribal governmental entity or industry group is itself a member; the membership is composed of organizations.

Members serve the group in three broad capacities:

(1) to represent their constituent organizations;
(2) to participate actively and consistently in TEC/WG activities; and
(3) to communicate the findings and recommendations of the group back to their organizations for further input.

TEC/WG Member Organizations:

American Association of State Highway & Transportation Officials
AFL-CIO, Transportation Trades
American Association of Port Authorities
American College of Emergency Physicians
American Nuclear Society
Association of American Railroads
Commercial Vehicle Safety Alliance
Conference of Radiation Control Program Directors, Inc. (primarily state agency directors)
Contractors Transportation Management Association
Cooperative Hazardous Materials Education (DOT Program)
Council of Energy Resource Tribes
Council of State Governments — Eastern Regional Conference
Council of State Governments — Midwestern Office
Emergency Nurses Association
Energy Communities Alliance (local governments adjacent to or impacted by DOE activities)
Federal Railway Administration State Rail Safety Managers Program
Hazardous Materials Advisory Council (non profit educational association)
International Association of Fire Chiefs
International Association of Fire Fighters
International Association of Emergency Managers
International City/County Management Association
Intertribal Transportation Association
League of Women Voters Education Fund
National Association of Chiefs of Police
National Association of Counties
National Association of Emergency Medical Technicians
National Association of Regulatory Utility Commissioners
National Sheriffs Association
National Conference of State Legislatures
National Conference of State Transportation Specialists

(From: http://twilight.saic.com/TECWG/membersh.htm. This site contains links to information on each organization including a profile of the organization and contact information for TEC members)

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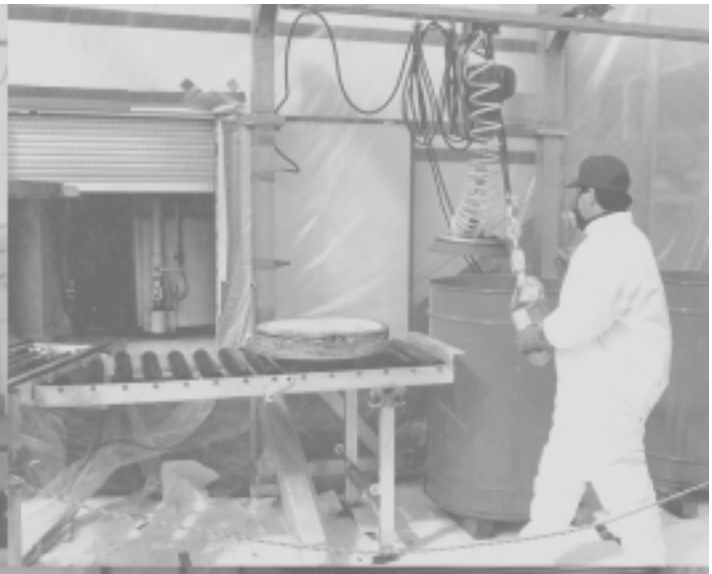

A Guide to

U.S. Department of Energy's Low-Level Radioactive Waste

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